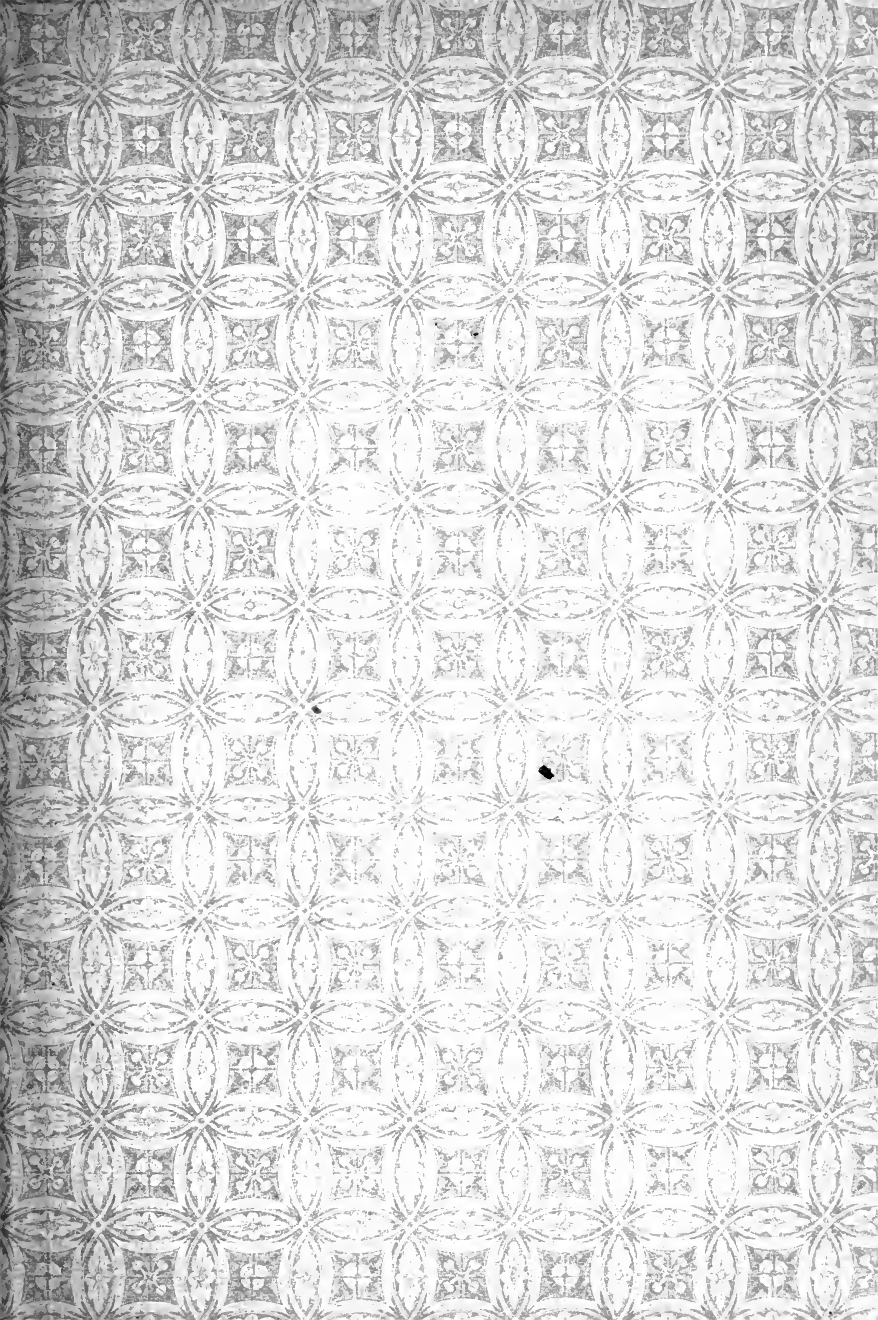
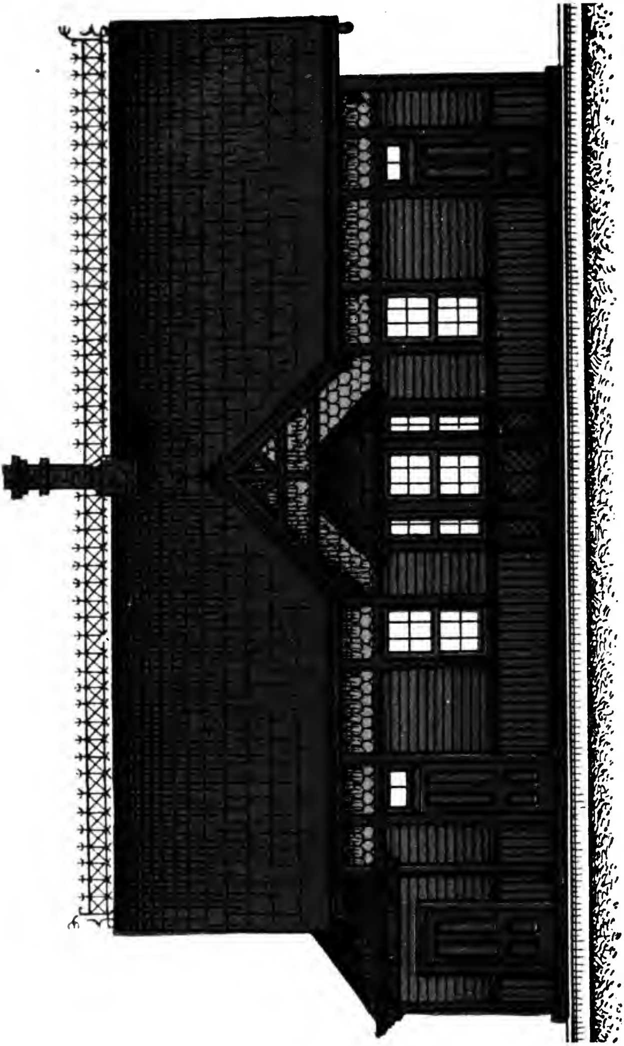
PAINTING



IN ONE VOLUME:

PART 1.—FUNDAMENTALS.
PART 2.—FINER PAINTING.



Painting
and
Painters' Materials:

A BOOK OF FACTS FOR PAINTERS AND THOSE WHO USE OR DEAL IN PAINT MATERIALS.

TREATING OF OILS IN ALL THEIR RELATIONS TO PAINT AND COLORS; OF PIGMENTS, THEIR QUALITIES, USES, CHANGES, ADULTERATIONS, AND TESTS; VARNISHES, THEIR MATERIALS, COMPARATIVE QUALITIES, USES IN DECORATION, AND THEIR MYSTERIES AND CHANGES IN USE; OF DRIERS AND THEIR EFFECT IN THE DRYING OF PAINT AND VARNISH; OF WOOD AND IRON AS PRESERVED BY PAINT, AND THEIR RELATIONS TO CRACKING AND PEELING OF PAINT AND VARNISH; OF THE MANAGEMENT OF PAINT SHOPS, CARRIAGE PAINTING AND CAR PAINTING; OF DECORATION AND THE USE OF COLOR; AND OF THE EFFECTS OF PAINT ON HEALTH.

BY CHARLES L. CONDIT,

UNDER THE SUPERVISION OF

JACOB SCHELLER,

MASTER PAINTER.

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PREFACE.

Skillful brushing and coloring do not come by reading books ; printed words at best furnish a clumsy method of showing the nice manipulation of a mechanical operation. Such teaching is better left to the shop; but in the shop one will not always acquire requisite knowledge, and will seldom or never get it formed and definitely shaped, as a printed record may shape and form it. Hence the opportunity of a text book, which shall attempt to do what the shop leaves undone.

It is thought necessary to speak of what may be called scientific aspects of the subject treated in this little volume. Its point of view is here also practical, technical statements (tables, measurements, etc.), are used to give definiteness to practical certainties. Three questions will indicate the method of investigation : What is the practical evidence ? What has technical investigation discovered or made probable ? Do the results of technical investigation fit the conclusions of large experience ?

Mr. Scheller is, in fact, joint author of this book ; it is also indebted to Mr. Drummond and to Mr. Day for valuable assistance in the preparation of the sections bearing also their names. Any responsibility on their part is, however, *limited to these sections*. To G. J. Mulder's Die Chemie der austrocknenden Oele is due the ability to give a clear exposition of the process of drying and to show wherein the quality of one paint differs from that of another. The tables of "oil drying," are due to Mulder, where not attributed to Chevreul, whose work has also been helpful. In view of the practical evidence, the writer has restated positively some points implied rather than clearly stated by Mulder. J. G. Gentile's Lehrbuch der Farben-fabrikation has been the source of much information about pigments. Many debts are also due Notes on Building Construction, Von Bezold's Theory of Color (translation) and especially to Prof. Rood's Modern Chromatics. At the close of the volume the reader will find a brief bibliography.

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PART I.

* * * *"It seems to me most essential to call the attention of those engaged in the business of coach painting to the great advantage, if not the actual necessity, of acquiring something more than a mere superficial knowledge of the materials and compounds continually passing through their hands, and of the conversion and application of such materials which play so important a part in their daily vocation."*—THE HUB'S Prize Essay on Carriage Painting.

CHAPTER I.

THINGS IN GENERAL.

Considered as a useful art, painting is a process of water-proofing. It is its special service in construction to prevent wood and iron from becoming moist. The painter's first duty is, therefore, to understand the action of water upon these substances, and especially how to prevent it.

1. The action of air alone upon seasoned wood, even if the air contains considerable moisture, does not cause it to rot. The woodwork of ancient churches and cathedrals in Europe has remained sound, although exposed for centuries to air and without paint. Tredgold says, "For timber that is not exposed to the weather, the utility of paint is somewhat doubtful."

2. The action of air containing not more than the usual moisture of air in our climate is to swell and split wood rather than to rot it. In preventing this action of moist air, therefore, we need to treat all sides of the wood facing air. These are practically all sides of the wood not in immediate contact with some solid substance.

3. The first cause of decay in wood is the presence of sap. Painting on such wood only prevents the water of the sap from escaping, and in the confined air the fermenting sap rots the wood the faster. The water also in seeking to escape may raise blisters upon the paint, as will be discovered by picking the blisters, when it will run out. It is probable also that

seemingly empty blisters are formed by the gases of such painted wood.

4. The second and most active cause of the destruction of wood is dry rot. This comes with the growth of little plants (fungi) which feed on the woody fibre. They thrive best in warm, damp and close places, as under the floors of warm cellars or basements, but once fairly started are able to live even in a current of not too cold air. Timber built into walls, or over walls not yet dry, is specially subject to it.

Painting over unseasoned timber is also favorable to it—as in fact anything is which shuts out the air from moist but not too damp wood. A piece of timber apparently sound may be full of dry rot, as may be discovered by boring into it.

Wet rot is the general name given to the rotting of wood due to moisture, but not to the presence of the dry-rot fungus. The painter has more to do with this than with dry rot. He should strongly advise that no two pieces of wood should be put together until their surfaces have been covered with paint, unless they are to be protected by their position from all access of water.

In his own special work the painter will see that all cracks are filled with oil and white lead or good oil putty, and that they are thoroughly filled, not merely skimmed over.

5. The alternate wetting and drying of wood causes decay, but of uncertain rapidity on surfaces exposed to free sunlight and air. The painter is more concerned with the checking, swelling and warping caused by such exposure, and also by that roughen-

ing and breaking up of fibres which unfits the surface to be a foundation for fine painting.

(a) To sum up the matter in a word : *all wood containing or exposed to moisture (and not submerged in water or earth) needs treatment in proportion as it is shut out from free access to the air.*

(b) On the other hand, to shut out air from wood is to hasten its decay unless the wood remains quite dry.

(c) Under the ordinary division of labor among the trades it falls to the painter mainly to prevent the warping, swelling and checking of wood, and the consequent opening of joints and cracks.

We shall return to this subject.

RUSTING OF IRON.

Iron will not rust in perfectly dry air; the presence of some water is necessary, and it rusts more rapidly in warm countries than in cold countries and in warm than in cold weather. Cast iron rusts least rapidly, wrought iron perhaps 25 per cent. and steel about one-third faster.* The presence of acids (as carbonic acid) is especially active in causing rust.

Rust contains water, and by its own action causes rust. It is necessary, therefore, to prevent its beginning at any point, or it may extend rapidly over the entire surface, and even under those portions which have been painted.

Galvanized iron is protected from rust only so long as the entire surface is perfect ; if broken at any point, the action between the two metals may soon destroy the covering of zinc.

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* It is doubtful whether steel rusts more rapidly. It probably does *not* if the black scale (black oxide) is removed. Steel should, perhaps, be said to rust more irregularly rather than more rapidly than iron.

The black (scale) oxide of iron which forms on heated iron (but is apt to scale off rapidly and easily) is a protection to iron against rust. In painting iron it needs to be removed because it so readily becomes loose, carrying the paint with it—from steel because it produces "pitting."

The black magnetic oxide of iron (produced by exposing iron to a temperature of 500 to 1,200 degrees in a chamber containing superheated steam) is probably its best protection against rust, as this oxide remains attached to the iron, and if detached at any point by violence the rust does not extend from that place to the others covered by the oxide, as it might do in the case of paint or zinc-covered iron. This method is known as the Bower-Barff process.

Very thin plates of iron rust more rapidly than thick plates, because the scales of rust are thrown off by the greater expansion and contraction of such plates, exposing, as they do, so much surface to heat and cold.

To sum the difficulties with iron: (1.) Iron rusts in the presence of even moist air. (2.) Although the black (oxide) rust protects the iron, it easily scales, while the red rust itself produces rust, which is not the case with substances forming under like circumstances (to a degree) on zinc and copper. (3.) Paint has little to hold by on smooth iron; and (4), the rust can spread under it from any rusted uncovered point. (5.) Finally, the expansion and contraction of iron under heat and cold tend to crack the unelastic layers of paint.

Frequent inspection, brushing away the points of rust and retouching the bare iron, and finally frequent repainting of the entire surface, form the only sure protection to the surface of painted iron. For further facts about iron see *Rust* and *Painting Iron.*

CHAPTER II.

THE CRACKING OF VARNISH AND PAINT.

Varnish and paint disappear in three ways (1) by cracking, (2) by peeling, (3) by perishing.

These are simple processes; it is quite easy to assign causes for them; but this, as we have found, is not quite the same as discovering what the true and most active causes of destruction are.

The principal agents in destruction are undoubtedly the sun, water, cold, the oxygen of the air and the friction of storms of wind and rain. Paint not exposed to the sun, to violence or to moisture will last a very long time. Paint is of the same nature, whether it is on a canvas or a carriage; and the study of facts about pictures will give us much light about carriages. Dr. Liebreich says:

> "The amount of external injury oil paintings sometimes endure and stand is perfectly amazing. Pictures in the course of centuries, during the destructive fury of wars and revolutions, may have been torn out of their frames, rescued from below the ruins of burned monasteries, may subsequently have passed from one *bric-a-brac* shop to another, where they have been piled up to be pulled about at each new inspection, and literally trodden under foot, whereby they have finally been reduced to a state of colorless, grayish, or black rags. Still such pictures may not unfrequently be awakened, as it were, to new life, to their original briliancy of color, if, with all necessary care, their injured limbs are put together again, their wounds are healed, and fresh nourishment, air and thorough cleansing are administered to their lacerated bodies.
>
> "A sound constitution is, of course, a necessary condition for obtaining any such result; without it we can only obtain a partial cure."

Prof. Max Pettenkoffer, one of the ablest scientific men in Europe, has, fortunately, investigated the decay of varnish and paint on pictures. Many old pictures become invisible by a change in the varnish, formerly supposed to be due to mold. This was proved to be a mistake, and the true cause of the whitening and lack of transparency shown to be partial separation of the gum of the varnish from the hard, dried oil. A piece of window-glass becomes white and no longer transparent when ground to a powder, without any change in the substance of the glass—merely a change in its form. Pettenkoffer proved that this powdering of the glassy varnish was due to the evaporation of water which had been deposited by the air upon the surface of the picture; and he produced a like result by frequently wetting the surface of a picture, allowing the water to evaporate as if put there by natural means. The immediate cause of the whitening is, as we have said, the resulting separation of the varnish gum from the oil in which it is held.*

In the great gallery at Munich, 52 per cent. of the pictures in rooms with a northern exposure were found to be more or less affected by this powdering of the varnish; in rooms with a southern exposure but 10 per cent. were so affected. We may, therefore, rest quite certainly on the fact that the evaporation of moisture has much to do with the decay of varnish. The influence of moisture is the more evident from the fact that other galleries than those at Munich suffer less from moisture and more from

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* For proof and further explanations see *Changes in Varnish*, under Carriage Painting.

other causes. The dampness of these galleries compared with the dry and brighter warmth of those in Italy shows that only the *direct* influence of the sun is injurious to paint ; to direct sunlight and the rain, hail and snow, we must look for the destructive agencies which lie outside the paint itself.

CRACKING.

Intending to return to the consideration of perishing, we may here profitably study the cracking of paint and varnish. One turns naturally to contraction and expansion of wood as a cause of this cracking upon all wooden structures.

The following table, the result of French experiments, is interesting in this respect :

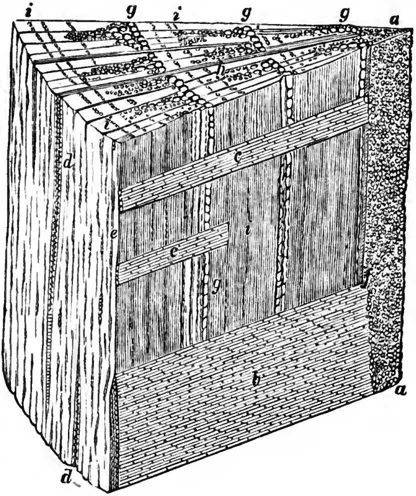
Increase of Measurement when Thoroughly Saturated with Water. The Increase Represents Proportion to 100 parts of Measure.

	Length.	Breadth.
Maple	0.072	3.350
Apple	0.109	3.000
Birch	0.222	3.860
Pear	0.228	3.940
White beech	0.400	6.660
Purple "	0.200	5.030
Box	0.026	6.020
Cedar	0.017	1.300
Ebony	0,010	2.130
Young oak	0.400	3.900
Old oak	0.130	3.130
Young ash	0.821	4.050
Old ash	0.187	3.840
Fir-wood	0.076	2.410

Perhaps more satisfactory measurements have been made in Germany by Karmarsch, which are so valuable that we give them also in full.

Amount of Shrinking of Green Wood in Percentages.

KIND OF WOOD.	In length.*	CROSS SECTION.	
		Directly through.†	In direction‡ of yearly rings.
Maple	0.062 to 0.200	2.0 to 5.4	4.13 to 7.3
Pear	2.228	2.9 to 3.94	5.5 to 12.7
Red beech	0.20 to 0.34	2.3 to 6.0	5.0 to 10.4
Oak	0.028 to 0.435	1.1 to 7.5	2.5 to 10.6
Ash	0.187 to 0.821	0.5 to 7.8	2.6 to 11.8
Pitch pine	0.076	1.1 to 2.8	2.0 to 7.3
Fir	0.008 to 0.201	0.6 to 3.8	2.0 to 6.8
Larch	0.013 to 0.288	0.3 to 7.3	1.4 to 7.1
Mahogany	0.110	1.09	1.79
Walnut	0.223	2.6 to 8.2	4.0 to 17.6
Poplar	0.068 to 0.62	1.2 to 4.2	2.8 to 9.8
White pine	0.086 to 0.122	1.7 to 4.82	4.1 to 8.13
Elm	0.014 to 0.63	1.2 to 4.6	2.7 to 8.5



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* In line *a* to *a*. About 1-10 of 1 per cent.
† In line of layers marked *c*. About 5 per cent.
‡ In line of *i* to *i*. About 10 per cent.

It will be seen that the expansion of wood due to moisture is from 5 times (in young ash) to 213 times (in ebony) greater in its breadth than in its length. One would naturally expect, therefore, to find cracks in paint and varnish parting as the fibres of the wood part—namely, parallel with its grain.

The facts are that those cracks, extending with the grain, are much less numerous and of less importance than those extending across the grain. Within the house, or car, nearly all cracks run at right angles to the grain of the wood. Out of doors, except with very green wood or very poor materials, cracks of much consequence do not appear in the wood until this has become dry and shrunken, and has expanded again in some "spell" of bad weather, or by the admission of water through cracks in paint or varnish, which cracks first appeared across its grain.

It is surprising how much a door or panel may shrink without cracking its paint—at least without cracking it as wood always "checks," namely, with its grain. The reason is very simple. In the shrinking of wood, every little fibre comes closer to its neighbors, and the larger fibres, especially, raise the paint or varnish in little folds, which remain as so much "slack," ready to be stretched again.

The strain at every point, whether from contraction or expansion, is thus made very gentle, as one may see from the fact that a deep "check" in the wood cracks varnish only when and at that place where the wood itself is torn apart. Previous to this the total strain in the wood must have been very considerable, but it did not crack the varnish.

The contraction of wood in breadth, and its small contraction in length, may, however, give *direction* to the cracking of paint and varnish. If the contraction of the paint or varnish upon itself produces the cracks, then the greater contraction of the wood in breadth will prevent cracks extending with the grain of the wood. Even this, however, does not seem to be the principal reason why varnish and paint crack at right angles to the wood fibres.

Does Heat Crack Varnish?—In order to make sure that the contraction of wood has little effect on good paint or varnish, one may observe the influence of heat on painted surfaces.

Heat does not crack paint or varnish; in constant heat both are made elastic. The cabs on the locomotives of a railroad afford an excellent illustration. These locomotives have unusual care, and are well varnished. Nearly all outside and inside surfaces of the cabs are, nevertheless, cracked across the grain of the wood. The exception is the ceiling of the cab, which is at times so hot the hand can hardly be allowed to remain upon it. The wood is badly shrunken, but the varnish is fine and glossy, without apparent cracks, except a few above the side windows, and these are across the grain. The panel back of the steam-gauge is also free from cracks, while the sash of the small windows on either side are full of fine cross-grained cracks. The panel is thick and protected; the sashes are thin and exposed to the cold air, for it is the cooling which cracks varnish. Varnish and paint crack, as a rule, from contraction in their own substance. The effect of heat is to expand and soften varnish.

Heat also unites the separated varnish, as a clouded and whitened varnish surface can be made clear by heating.

Let us now examine the positive side of this cracking.

1st. On a perfect surface paint and varnish have no special direction of cracking, but may part in all directions. On leather, or any pressed or stretched surface, cracking quite often takes a circular form, one circle outside another.

2d. Cracking will occur at that point where the strain is greatest and there is the least elasticity.

3d. The cracking of paint and varnish on wood is controlled commonly as to its *direction* by the fibres of the wood. If we place together two pieces of wood with smooth surfaces, it will be found that they can be rubbed much more easily with than across the grain. Across the grain each little fibre is meeting resistance from each fibre on the other piece, especially from those larger ones which mark the close of each year's ring or growth. If we place a drop of oil upon a smooth piece of wood, and let fall gently into it other drops, the oil will be seen to move further with than across the grain. Each added drop will make this fact plainer, and if a glass "dropper" be used, the difference between the results of pointing the force of the drop with the grain, or across the grain, will make the fact still more marked that all movement on the surface of wood is easier with the fibres than at right angles to them.

In all contraction of the paint upon itself, therefore, the movement (contraction is movement) will be easier with the grain than across the grain. This will tend to open cracks across the grain.

An Experiment.—For a test, Messrs. G. W. Read

& Co. sawed for us from the damp log, one piece of whitewood, and several of black walnut. These were planed and varnished with four or five coats of common rubbing varnish, one over the other in quick succession. After a few days (meanwhile remaining in cold room) they were placed under a powerful heat for about fourteen hours of each day for a week, the unvarnished and then the varnished side being exposed. The wood was by this time very dry, but no cracks appeared in the varnish, although the whitewood had become badly warped. The whitewood was then soaked in water until it had warped in the opposite direction to the shape of a bow, when it was again exposed to heat until dry. The soaking produced some cracks, with the grain, and a few cracks appeared, caused evidently by this second baking, as a few indicated by their shape that they were controlled by the warping. But the cracks were hardly cracks at all, and it would now, many months after, be difficult to find them without a glass.

This experiment shows very plainly, that at least until it loses its elasticity wood by *contraction* does not crack paint or varnish.

Cracks with the Grain.—Many cracks extending with the grain of wood are no doubt due to the expansion of the wood by moisture. They point to the fact that the wood has not been properly protected from moisture. Even if painted on one side, wood in the interior of the house gains from 3 to 6 per cent. of its weight of water in summer, and loses it again in winter.* The gain and loss of wood ex-

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* This fact I have through the kindness of Professor Brewer, of Yale College, who averaged for me the result of very extended but still incomplete experiments. The figures are true of small not very thick pieces.

posed to the weather must be much greater than this. We cannot entirely prevent the action of moist air on wood, but this is not necessary. Good paint and varnish properly used will not crack on this account if the wood is reasonably protected. I speak here of severe cracking; small cracks, of course, will appear, but these are of little consequence. They are easily covered, as are any spots of "perishing." The *fatal disease in paint and varnish is severe cracking.*

Cracks Across the Grain.—The best examples of cracks across the grain of the wood are those to be found on carriages. A carriage spoke almost invariably cracks in a circle, or some arc of a circle, across the grain of the wood.

A jar will crack varnish more or less across the grain of its wood, as may be seen on that part of the carriage to which the mounting steps are attached. The jar on the wheels undoubtedly does aid in the cracking. I have made one experiment with a comparatively crackless spoke, and have produced cracks by striking it upon its end. These cracks have a tendency to run diagonally across the grain, some also directly across. On some spokes, at least, it will be observed that the larger cracks are half circles in the central part of the body of the spoke, extending from and to, but not crossing, a line on each side drawn from each side the tenon, and are much more frequent near the hub.

But notwithstanding all these appearances, the facts appear to be that even on spokes it is not the strain and jar which cause these cracks across the grain. Out of 50 show spokes hanging in a paint shop 48 were cracked in more or less complete circles around the spoke. The reason why varnish on spokes has more tendency to crack near the hub is because there is more varnish left there.

Cracking on Carriages.—Cracking first appears on the felly or rim of the wheel, and is partly caused by the strain, and partly due probably to the effect of mud and other substances on the paint and varnish. The cracks almost invariably extend across the grain, because the strain will stretch the varnish in this direction in much the same manner, as though the felly were to be straightened to a flat piece.

On the body the cracks are generally across the grain; but not always, because if the cracking does not begin in coats next the wood, but in the varnish coats, the wood fibres have no influence on the direction of the cracks, because they are completely covered by the filling coats. On the top of coaches, the cracking is often caused by a change in the muslin, and may often be the fault of the method of covering. It is also caused by the amount of white lead, etc., which is placed *under* the canvas. It is probably better to glue on the muslin. It may also be caused by the white lead over the canvas, if it has not been properly dried or contains too much oil. The roof panels may also cause cracking; but as the muslin, etc., lies between it and the varnish, the fibres of the wood can have no influence over the direction of the cracks.

On light wagons, cracks under the seat-board are caused by strain. On carriages and coaches exposed to a rain (for such it seems to be) of ammonia in stables, cracks will be found on upper and less covered portions, while none may exist where the varnish has been protected from the shower of ammonia. Usually, those parts of a carriage least exposed to (1) street mud and (2) sun, are not cracked, or if they are, they indicate a poor job, hence these portions are the better places to observe as test. Other parts of the carriage may have had good work, but hard usage or poor care—as, for example, frequent washings with poor (*i. e.*, alkaline) soap.

Cracking on Cars.—On cars with good surface, small cracks will run in all directions. The larger cracks are generally across the grain of the wood, beginning often at the edges of the panel near panel strips, because at this point a greater thickness of paint and varnish is found. Occasionally one finds a car with long, deep cracks extending with the grain of the wood. It is possible that in these cases the wood may be at fault, but if so it shares the blame with the rubbing varnish. But even if the wood be at fault in these cases, it is the expansion and not the contraction which causes the cracking. I cannot prove this, but think it might be proved by careful observation and experiment.

Within the car nearly all cracking extends across the grain of the wood. Fewer cracks will be found on veneered surfaces, and these not always across the grain, probably because the shrinking of the wood on which the veneer is placed has some influence.

Interior of Buildings.—Cracking is usually across the grain, except about window sills and on doors exposed on one side to damp air.

Exterior of Buildings.—Failure to treat more than one side of the wood used in building (clapboards, etc.) shows very plainly in cracking of paint on buildings, which is often with the grain of the wood. These cracks are not entirely caused by the wood, but proper treatment of all its sides would better preserve the paint.

Cracks on Furniture.—The cracking of varnish upon furniture is quite uniformly across the wood fibres, except in the case of veneers, which occasionally offer an exception, owing partly to the peculiar way in which they are cut, and partly perhaps to the effect of the wood on which they are fastened. Old furniture, not cracked, if examined with a magnifying glass and the light reflected from the surface of the varnish caught with the glass, will be found to have numerous straight lines running across the grain. These are probably due to the parting a thin layer of the surface varnish which has lost its substance by slow decay faster than the coats beneath it. To sum up the decay of varnish:

1st. Properly treated wood has little destructive influence on paint or varnish.

2d. The so-called "perishing" of paint or varnishing is of less consequence, except as a preliminary cause of cracking. It is easily cured by other coats.

3d. The great and fatal diseases of paint and varnish are cracking and peeling.

4th. Varnish very largely (and paint to a degree) furnishes the force which cracks and destroys it.

5th. If these conclusions are trustworthy, we have these practical rules: (a). Cracking of varnish or paint upon wood in a direction across its grain indicates poor material or an improper use of good ones; *i. e.*, the coats not being old nor exposed for many hours per day to direct sunlight, and sufficient time (which is not often the case) having been allowed for the painting. The painter's most practical question is, how safely to save time.

(b). If the direction of the cracking is with that of the wood-fibres, the gain of moisture by the wood is to be suspected. The wood has not been properly protected on some or all sides.

(c). Any strain, however brought on the varnish, tends to open cracks across the grain because it is more bound in this direction, and moves more easily in the other—*i. e.*, with the grain.

CHAPTER III.

THE PURCHASE AND MANUFACTURE OF VARNISH.

As a rule, with few exceptions, varnishes will be purchased; information as to manufacture may, therefore, be limited to a purchaser's needs, and to some notes on the simpler varnishes.

There is more difficulty than mystery about the manufacture of varnish, and this difficulty arises from lack of means of testing the materials used, the heat of the fire, etc.

Varnish is made of oil, turpentine and resins. The quality and manipulation of each of these materials determine the quality of the varnish.

Varnish makers are perhaps inclined to feel that other people know very little about varnish, and other people are perhaps quite as likely to get their heads full of notions as of hard facts about varnish. On the other hand, varnish makers know much less than they should. The whole subject is in that "practical" stage of knowledge where a notion is in danger of getting more valued by everybody than is a scientific fact.

The facts seem to be: 1. The hardness and part of the durability of the varnish depend upon the resin. The less water the resin already contains, the less it is affected by the air; and for this and other reasons, the less by water. The air oxidizes the resin as it does the oil, but hard resin protects the oil from the air. Water separates the fine particles of resin from the oil.

2. The oil gives the varnish its elasticity; if it has been made into soap or contains much drier, the elasticity of the oil is destroyed. Better for durability a poorer resin and more good varnish oil than a better resin and poor or little oil.

On the other hand, the more oil in the varnish the more skill needed in using it coat over coat. Also the more skill needed in making it a varnish.

In selecting a varnish, as we shall see, three facts cannot be left out of account: 1. Who is to use it? 2. What is to be put under or over it, now and by and by? 3. When will it be used, and how much time will it have to dry?

The Resins.—There are in all about thirty different resins used in varnish making—different in name, and many possessing peculiar qualities. The best of these resins are fossils, that is to say, they are dug out of the ground or are found in the beds of rivers where they have lain for unknown years. All of the fossil resins are from trees, which may for practical purposes be called species of pines. The hardness of resin appears to depend upon its age and the amount of pressure it has undergone in the earth. See *Theory of Linseed Oil.*

Amber.—This, the hardest of all resins, is found in layers or mines on the coast of Prussia. Only refuse, or so-called "black" amber, is used for varnish. The trees from which came the amber grew, perhaps, when no men existed on this earth. "Amber" varnish usually means merely amber-colored varnish.

Copal.—Next in hardness to amber is the best copal from Zanzibar (Africa), called by the English *animi.* It is very difficult to dissolve, and practically there is but one method in use—namely, distilling the resin until it loses from 20 to 25 per cent. in weight. It may then be dissolved in boiling oil. Zanzibar copals are of three sorts in many grades; the better sorts give most lasting varnishes, but with more tendency to crack.

Sierra Leone Copal is much used in English varnishes. It has nothing to do with Sierra Leone, but comes from the river beds of the interior. It is the only African copal which is dissolved in cold alcohol. Its color is not always so good as Zanzibar, or the best Kauri copal, but it is harder than the latter. In English varnishes it is mixed with Zanzibar (or "animi"), the Sierra Leone giving elasticity, the animi hardness.

There are also of African copals. *pebble*, *ball* or *glass*, *Accra*, *Loango*, *Gaboon*, *Congo*, and the three sorts of *Angola* and one of *Benguela.*

The pebble, ball, best Loango, red Angola and the Benguela are much esteemed—the white Angola being the softest its softer kind sticking to the teeth when chewed. The pebble (or pebblestone) is the hardest of these copals.

The Kauri or *Cowrie*, of New Zealand, is, however, the principal copal used in America—its consumption being probably ten times greater than the combined quantities of those already mentioned. It is from two to nine times cheaper in price, is more colorless, very easily dissolved, and gives, therefore, a clearer varnish than any other copal resin. It is allied in chemical composition to the dammar resin; it melts more easily than mastic, but less easily than rosin.

Its great defect is its quick loss of lustre—the loss of the prime requisite of a varnish. A varnish made from the best selected pieces of Kauri gum holds its lustre second to a mixed Sierra Leone and Zanzibar copal varnish, but lower qualities go quickly. The loss of lustre does not cause loss of protecting power; the substance of the varnish remains.

Animé.—This was the original name given to copal, from the fact that it contained insects embedded in the gum. It is now the technical name for South American copal. This copal is from Brazil, and is not found in our market.

Manilla.—There are two sorts (neither fossils), a harder and a softer, from the Phillipine and other islands, Borneo, Singapore, etc. They find a large market here, and are used in varnishes alone and with harder resins.

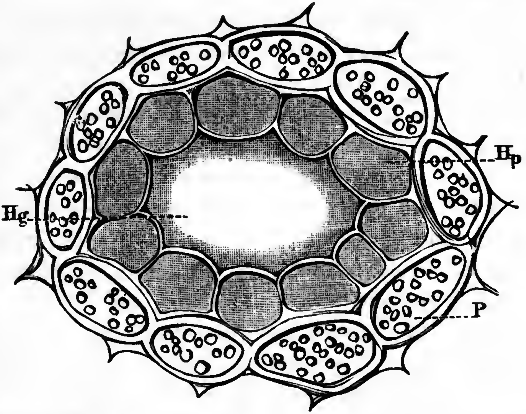
Rosin is too well known to need many words. By it, however, we may illustrate the making of resin in the tree. All resins are dissolved in their natural turpentine; they are entirely different from mucilage.

Mucilage is a *cell wall* (see cut) dissolved by water: the mucilage of the linseed, for example, which soaks up the saliva from the mouth, swells up and changes into a sweet slime. A resin is a secretion or perhaps a waste-stuff (excretion) of a tree or plant.

The resin which we now use for varnishes flowed out ages ago in a fluid state, often catching and holding the feet and then the bodies of insects lighting upon it. By various causes, gradual or sudden, it found its way underground. There it was pressed upon by the earth. To the action of the oxygen of the air and the pressure of the earth, its hardness is due. The harder resins contain least water; dammar, which is a recent resin, the most water.

The following are the average prices and the order of quantities of the different resins, as used in American varnishes:

Order by quantity.	Prices per lb.
1. Kauri	10 to 50 cts.
2. Manilla	10 to 25 ''
3. Dammar	16 to 25 ''
4. Zanzibar, best	$1 to $1.25
5. Benguela	85 ''



Section through a resin passage of *abies excelsa* (fir and spruce trees). The cavity *H g*, as well as the thin walled cells *H p*, are filled with semi-fluid resin. The thick wall cells *P* contain starch.

English Varnishes.—The great market of the world for resins, as well as for money, is London. English varnish-makers have, therefore, the first opportunity, and English varnishes have always been the best in the world, *i. e.*, the best varnishes (as we used to say in the old anti-slavery days) *per se.*

American Varnishes.—The poorer sorts contain rosin and many other things ; the quality of the better sort we have discussed below.

Qualities of Varnish.—The following may be given as the qualities of a good varnish :

1. It dries within 30 hours so as no longer to be affected by dust, and presents after three days a brilliant, firm surface with no spots of dull or fatty aspect.

2. It retains for *at least* 9 or 12 months a clear, elastic and transparent surface.

Color is not important, unless it refuses to bleach to colorlessness in a thin unstopped vial exposed to sunlight for three to five days.

The durability of varnish must be tested by trial. Prime a smooth board with white lead and oil, let it dry, then give one coat of varnish or one coat of several kinds of varnish in squares. Expose to the weather, and make observations from time to time during one year. Don't trust yourself to make this test unless you are an honest man, and do not use "samples" of varnish for this purpose. Samples sometimes are less durable than a regular article drawn from a barrel, sometimes they have more durability. It is not advisable, therefore, to trust samples. It is also much better to prepare three boards than one, as slight differences are due to position ; for example, either end of an upright board will give a severer test than the centre.

Such a test, honestly made, is fair, and, if duplicated and repeated, quite satisfactory.

The question arises, however, what is to be the standard of judgment. A *kauri* gum loses its lustre much sooner than a true copal gum, although the best grade of kauri follows well after copal. The loss in lustre is not, however, loss in protecting power either from water or dust. It is, however, loss of the principal quality for which varnish is used, namely, *reflections of white light.* It also may show the gum to have lost its power of clearing itself of water from its surface, and is certainly on the first step in decay.

Cracking should be observed. The more oil a varnish contains the larger the cracks. Fine cracks are of little account, because they do not prevent repainting or revarnishing. Large cracks, however, are a serious matter.

It follows that the most elastic varnishes, and those containing the most durable gum, have the disadvantage of producing, when they crack, the largest and longest partings of surface. This is the case with English varnish. No varnish is so durable. It is elastic, and retains its lustre for a long time—longer than any American varnish.

In winter it dries to a fine, hard, very brilliant and durable surface; but in the warmer months, it dries with a "tach," on which one might gild. English varnish is therefore not fitted for summer use.

Again, one must know what one puts over English varnish. It will do with its own, but if even two, or two and a half years after a coat of English varnish has been used, an American varnish be put over it, there is a large percentage of danger that both will crack in large cracks, running in several directions, but with a tendency to change to a direction at right angles with the grain of the wood. Whoever varnishes or repaints a car or carriage on which English varnish has been used should know that fact, and it would be advisable in buying a car or carriage to get the information at the time. An English varnish needs a strong and not too quick varnish over it, and is more dangerous as a basis for repainting than American varnish.

Varnish-makers think and speak most of *perishing;* but this is not the worst of evils of varnish, because it is so easily cured by a second coat. A varnish should, however, hold its lustre for ten to twelve months.

On the whole, therefore, while American varnishes "perish" more quickly, more quickly lose their lustre, have less oil, are less elastic and less durable, they are to be preferred for general use.

They crack in fine checks, neither large nor deep; they are safer as a basis for repainting, and less dangerous to revarnish.

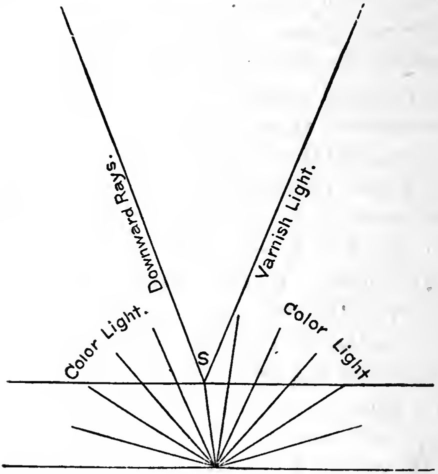
CHAPTER IV.

THE USE OF VARNISH.

A varnish may be called a liquid glass, and has much the same use as picture glass. A glass preserves the picture beneath it from water, dirt and injury ; a varnish does the same. Mulder, the able Dutch chemist, about whom we shall have much to say, recommends covering oil paintings with glass as the only effectual method of preserving them from the action of the oxygen of the air. Varnish over a picture preserves the oil colors beneath it, but is itself affected by the oxygen from which it protects them. For this reason it is much less durable than glass and may crack and injure the picture, or become cloudy and hide it. When a varnish over a picture becomes white and cloudy, it is generally because the varnish is no longer a continuous sheet like a transparent glass, but has changed into a fine powder, like powdered glass. A powder throws light in every direction, and is therefore not transparent ; a sheet of glass throws light in several regular ways, so that, by standing in a certain position and looking at a glass over a picture, we get the light reflected from its surface and see only a glassy lustre, through which we can barely discern a dim shadow of the picture.

To this peculiar manner of reflecting light, glass and varnish owe their power of bringing out colors. When we get the glossy lustre from glass or varnish into our eyes, the picture beneath seems dim because there is so much of this white glossy light mixed with its light. We are getting all the light there is from the picture, but our eyes do not see it because they are blinded by the brighter, glossy light from the surface of the glass. By taking another position, we see the picture very clearly, because our eyes no longer get the glossy light from the glass.

Glass and varnish over colors bring them out (as we say in familiar language) by leaving them alone.



Glass and varnish throw the white, glossy light out of the way, and the picture appears brighter to our eyes because it has less white light mixed with its light colors and shades than a picture over which there is neither glass nor varnish.

This power of varnish, its ability to bring out colors beneath it by leaving them alone, unmixed with white light from the surface, is a very important fact. We place varnish over finely colored woods in order to see more deeply and clearly into their structure by getting rid of the strong surface light which blinds our eyes to the feeble rays coming from below the surface of the wood. The glitter of varnish we do not want; it is hard, cold, meaningless light. The effects produced by the varnish are what we wish, because it enables us to see deeper than we otherwise would be able to do. Varnish, therefore, adds depth to a surface. A well-varnished surface is the opposite of a flat, dead surface. This impression of depth is both a fact and an impression of our minds; we *see* the contrast between the surface of the varnish and the deeper surface beneath it, but the difference between the two seems much greater than it actually is.

Therefore in using varnish there are two effects to obtain and one to avoid.

1. To bring out wood or paint in its own light by removing out of the way the white light which comes to our eyes from the top of the surface. Varnish by its lustre throws this white light out of the way for us; the lights and shades of the wood and the colors of the paint seem brighter because they are purer.

2. To give a pleasant illusion of depth to a surface by the contrast between the upper surface, or varnish light, and the lower surface, or color light. This depth gives a softness to color which is the exact opposite and contrast to a glitter of varnish.*

3. There is no doubt that a gentle twinkle is part

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* There are other facts in connection with the relations of varnish to light which might be added, but they are more difficult to comprehend. Varnish as the medium of light has an effect. Von Bezold and Rood discuss the matter from different standpoints.

of the attractiveness of a varnished surface, but the effect to avoid is throwing the glitter of the varnish into the eyes of the observer. Great care is taken in this respect, in hanging pictures, to get a position for them which will throw the glitter of the varnish quite out of the way. The only care which the painter can take is to reduce the glitter to just power enough to accomplish the desirable effects (1 and 2) without dazzling the eyes of the observer with the very white light, which it is his purpose to throw out of the way. Finish, therefore, must be adapted to the amount and kind of light which it is to get.

A darker room or a darker surface will bear a higher finish than a lighter room or a whiter surface. The principle is that effects Nos. 1 and 2 are always desired, and No. 3 always as far as possible to be avoided, and in this matter the angle of light falling upon the surface has, of course, great influence.

Rough-stuff and Rubbing Varnish.—Varnish has to do almost entirely with our eyes; it is a matter of light and not of touch. It is for effects of light that so much trouble is taken with rubbing varnish and rough-stuff. It is all a matter of throwing white light. If the white light is thrown in many different ways, from different spots, the surface appears full of hills and hollows. If the white light is all thrown in certain directions, the surface appears smooth; if the white light is only thrown out of the way in spots, the surface is broken into blotches of glitter and dull color; if the white light is thrown entirely out of the way, the deep, clear beauty of the surface beneath pleases the eye.

The question arises whether too much trouble and too much expense and risk are not often involved to produce a temporary effect of this kind. Why, for example, should all this trouble be taken with the surface of cars, which are to be almost constantly covered with cinders and dirt ?

It seems an unreasonable proceeding to spend weeks, or even days, in getting ready a surface which shall throw white light quite out of the way, and then as a light reflector use a cheap Kauri varnish, whose lustre dies in a few months, and with it, of course, those effects for which so much trouble has been taken. Still more unreasonable is it to endanger the protection and appearance of such an exposed surface as a car for the sake of a little more regularity in getting rid of a little more white light—for this is what is accomplished and about all that is accomplished by the use of rubbing varnish. Truly, it seems time that practical men should look at things as they actually are. Moreover, it is possible to give even a carriage so much *glitter* of finish that the eye is offended.

Rubbing Varnish.—Varnish depends for its elasticity upon the amount of oil it contains. Rubbing varnish must be not merely dry, but hard, within 24 hours after its application. It, therefore, contains little oil, and this is made into brittle soaps by strong driers. No coat, therefore, has so little elasticity for its bulk.

But this is not sufficient ; this non-elastic coat must be rubbed with water. Water evaporating upon a varnished surface tends to separate the gum from the oil, and thereby to decrease its elasticity still more. See *Apparent Changes in Pigments due to Changes in Oil.*

One of the difficulties in the way of getting rid of it is the danger of striping on flat color, but this may be avoided by using a coat of color and varnish, rubbing this with a bunch of hair, and striping upon it.

Where rubbing varnish must be used, it is well (knowing each varnish and testing the mixture) to mix rubbing with finishing varnish, half and half, or less of the finishing than of the rubbing if preferred.

A rubbing varnish should fill the following requirements:

(1.) It must be "sweat"—*i. e.*, it must remain flat and lustreless after the lustre has once been removed by rubbing.

(2.) It must dry hard and firm within 24 hours, in order to cut freely and easily when rubbed with pumice stone and water.

CHAPTER V.

TESTING THE QUALITIES OF COMMON PIGMENTS.

The usefulness of a pigment in relation to the oil will be thoroughly discussed; but we may first examine those qualities which have not to do with protecting, but with coloring properties.

These qualities are (1) covering (coloring) power, (2) kind and quality of color, (3) durability of color, (4) price.

Covering (Coloring) Power.—Cold-blooded people paint not to satisfy their sense of color but their sense of fitness.

"Color," says the first decorator of our time, "will never take real hold on the art of our civilization. Imitation and affectation may deceive people, but the deception will not last. To have a meaning and make others feel and understand it must ever be the aim and end of our Western art."

Nevertheless, color is more important than any other quality of a paint. In America, until now, we have painted with white as expressive of the strong American sense of neatness, but the fashion threatens to turn "bilious."

Many white substances are white because they are in fine particles. A white lily is white because it consists of little cells which reflect all kinds of light, again and again, until it reaches our eyes from some part of its surface. Water becomes white when it is broken into fine drops, as in a waterfall, or on the crests of waves. White lead and zinc owe their whiteness to their dense, fine, powder-like condition. Finally, transparent glass becomes white when it is ground into a powder.

Covering power is due to two qualities. (1) Whitewash made of lime and water has very little covering (coloring) power until it becomes dry. Barytes covers well as a water paint because, as in the case of whitewash, the water leaves it as a dry powder, but it covers poorly in oil, because the oil remains with it, and the light reaches it through the oil. Prof. Von Bezold has illustrated this curious and important question in the following manner* :

Experiment, illustrating how lime, barytes and white leads containing crystals become in oil more or less translucent, and therefore do not color the surfaces on which they are placed.

"If we fill the lower part of a small glass tube (a test tube) with coarsely powdered glass, the powder will appear white, and it will be impossible to see through it, but as soon as we pour water into the tube the powder will become translucent to a certain degree. By substituting turpentine for the water, the degree of translucency is considerably increased. Furthermore, if we add a small quantity of sulphuret of carbon to the turpentine, we shall obtain a liquid which reflects (bends) the light about as powerfully as glass, and if we now pour some of this liquid upon the powder, the latter will disappear almost entirely to the eye and we shall be able to look through the glass freely as if it contained only the clear fluid without the least particle of powder. If we immerse a glass rod in such a liquid (instead of which we may

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* Von Bezold, "Theory of Color," L. Prang Co.

also employ a mixture of olive oil and oil of cassia) it will appear as if the rod reached only to the surface of the liquid. Within the liquid the presence of the rod cannot be detected; it is perfectly transparent, as shown by the illustration. Instead of the powdered glass, small beads of transparent, colorless glass may be used. They will become visible as soon as the liquid dislodges the air between them.

"It is shown by these experiments that the presence of one transparent body within another is only betrayed to the eye when the two differ in their power of refracting light. If this is not the case, the light passes through the mixture without obstruction."

GENERAL TEST FOR WHITE PAINTS.—(Chandler.)

" Any white paint ground in oil may be tested by comparison with a pure article :

" Weigh out 100 grains of each paint to be compared, add 3 drops of linseed oil to each, and spread as nearly as possible alike on 6 × 12 glass, using a steel spatula for this purpose.

"Place the samples (thus prepared) between yourself and the light; the sample which shuts off most light, and appears darkest, has the greatest covering capacity and its purity may be inferred as it excels in this respect."

There are other questions connected with covering power which are too difficult to explain here; but the above facts will aid in making it clearer why some pigments lose their covering power in oil. White lead and zinc owe their coloring power partly to the fact that they are dense metals which are in fine powder. White lead as it ages loses some of its carbonic acid and covers less well than at first, so that a black color under it is not so much hidden as before. This is also to some extent the case with zinc white, but it is evident from the fact that the hydrated oxide of lead (see *White Lead*) has no covering power, that it is to a change in the condition of the lead by the carbonic acid that the whiteness is due. This change may be merely the reducing the lead to fine particles whose surfaces are very irregular, and therefore reflect light like so many pieces of glass ground to a powder. Certain it is that large particles of white lead whose surfaces are more regular and crystalline* do not cover so well.

(2) It seems certain, however, that the weight and smallness of the *particles* are the important facts. One of the best authorities says that, weight for weight, zinc covers as well as, if not better than lead but in a

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* From a Greek word for frost, reflecting light like ice.

greater number of coats. The same is true of the different sorts of white lead.

Mulder, the able Dutch chemist, estimates that three coats of lead are equal to five coats of zinc; difference in covering by these substances, therefore, is merely a question of labor; with fewer coats one can get a better covering, but will use the same weight of metal.

There is, however, another sense in which covering power is used, which is entirely different from the above. Zinc white is said to cover 33 per cent. more surface than white lead; and a good iron paint (as for instance the English Torbay paint) 62 lbs., as much surface as 112 lbs. of either white or red lead. Truly, but zinc white covers its one-third greater space with a thinner layer; and likewise with iron paint. Thickness of layer as a protection to iron must be taken into account.

Covering power has, therefore, three or four senses; protection to the oil, fullness of coloring to the surface, the amount of surface colored, and the thickness of covering resulting from the union between the oil and the pigment.

The kind and quality of the color is the second and all-important quality of a pigment. It decides against the use of red lead, which in many respects is the most valuable pigment there is. It also decides against the iron paints, which are in other respects the best of paints. He is the skillful surface painter who can produce cheap, quickly-drying, hard, durable paint of clear, deep and quiet hues.

In artistic painting, the problem is to produce lasting and durable hues which shall be clear and pure, free from all muddiness and change.

Durability of Color.—Zinc white is the most durable of white colors, sulphur gases changing it to a white sulphide of zinc, while the sulphide of lead is black. Zinc white has also less tendency to become yellow than white lead, although it darkens in the shade to a degree. Lead grows darker and more yellow with each year, wherever exposed to sulphur gas or deprived of the sun. Lead tends to powder, zinc to flakes or scales. White lead, being carbonic acid lead, is not affected by carbonic acid gas ; the carbonic acid in rain water changes the zinc (oxide of zinc) into carbonic acid zinc. The acids of unseasoned wood also have a great effect upon it (Dent). Although the carbonic acid is easily driven off from the white lead by even a weak acid, yet it is doubtful whether zinc has more advantage than durability of color over lead ; and whether lead will not in exposed positions hold out as long or even longer than zinc. For the interior of the house, zinc is the superior paint over a foundation coat of lead. Zinc is immediately less bright than lead, but can be improved by a little varnish (dammar or other varnish) and in time becomes very hard and takes a good polish.

Mixtures of zinc and lead are probably better than either alone, although one of the best painters in our acquaintance insists that it results in a tendency to crack. This opinion is not borne out by the experience of others of less intimate but larger experience. It may, however, be true. Many zincs contain sulphuric acid and, therefore, are in danger of darkening the lead (by producing sulphide of lead) or injuring its covering power by making sulphate of lead.

Barytes (*Sulphate of Baryta*).—This substance is a natural product, known abroad as heavy spar and also as an artificial chemical product (permanent white). It is found in this country in Virginia and several other states, and is washed and ground and mixed with anything which will allow of the mixture. A "floated" barytes, *i. e.*, a finer quality made by floating off and settling the finer particles, is also used. Artificial barytes has a greater covering power than the natural article, and is known as *blanc fixe*, permanent white, etc., and with sulphide of zinc makes up the new Fulton and other whites, although the Charlton White Company has recently taken out a patent for the use of strontia instead of barium.

Probably the larger number of tons of white lead used on this planet have contained barytes; and as an honest and acknowledged adulteration *not exceeding* 10 or 15 per cent., there is no proof that for outside work it is not a gain to both durability and price. Zinc lacks weight, and this the barytes has, and it is a wise addition to zinc for outdoor use where lead is not preferred (Masury).

Neither barytes nor any other substance which does not unite with oil is fit (by itself) for a paint.

Lead does not cover so well with barytes, but zinc in the best sense covers better—*i. e.*, protects better. I cannot speak from definite experience. As some pigments contain 90 per cent. of it, it is wise to listen to what can be said in its favor. One of the best authorities on paints, while he admits the injury to the covering power of pigments by an adulteration with barytes, gives it the credit of these advantages: (1) It brightens dark colors. (2) It injures chrome yellow less than it does some other colors. (3) It prevents pigments needing a large amount of oil to reduce them to the consistency of butter (as in prepared paints), from absorbing so much, by sooner producing this consistency.

Its principal disadvantage is its lack of covering power, and the ease with which it induces men to injure their own character as well as that of their paints. The best houses, however, sell no adulterated white lead under their own names.

An American chemist* who a few years ago investigated the adulterations of paints in our market, gives the following as his results:

A second-class zinc white:

Barytes	54
Zinc white	44
Other substances	2
	100

The adulteration of colored pigments by barytes is universal, but largely it is not dishonest, because the pigment is so made up for the price. There is, however, dishonest adulteration, also, here.

Iron Paints (oxides of iron mixed with clay, sand, etc., either naturally or with purpose).—No substances are more lasting. There are houses in Sweden which, says the chemist Berzelius (1838), have stood well preserved for 300 years covered with iron paint. Mulder suggests that the pitch in the wood was not without influence in this case. Another authority suggests the use of fish oil either with or over the paint, or else the paint was a sulphuric acid iron, boiled with the oil, producing a preserving fluid which little by little sank into the wood.

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*Henry G. Debrunner.

The only objection to these pigments for all outside work is their color. Aniline colors have been used with them (as prepared paints), but are not to be trusted. Burning any suspicious paint over an alcohol lamp will destroy the aniline and leave the reddish iron in its natural color, exposing the cheat. Sulphuric acid iron colors, however, are well suited to this purpose on wood, less so for use on iron.

These iron paints require a treatment which their price in this country hardly allows. They should be ground to the finest powder, and then ground again for some hours with oil of the best quality, as is the English Torbay. Unless they contain their full amount of oxygen in the natural state, they should previously be thoroughly roasted, when they become of a violet-red color. With age their tendency is to darken from loss of oxygen and the formation of black oxide of iron ; but their great durability is due to the fact that the air has so little effect upon their substance.

Red lead is a valuable addition both as a drier and as supplying the qualities (except color) which iron paints lack.

Iron paints are largely adulterated, naturally and otherwise, and the adulteration is an important consideration. Barytes, chalk and silica lessen the covering power ; but clay has the disadvantage of being affected by water. The best adulteration is pure silicon—quartz, sand, etc.

Test is difficult except by analysis. A magnet may be used to discover whether there is *any* iron in the paint ; but the quantity of clay present is not easily ascertained.

Ochres.—These are clays naturally tinted with oxides and manganese containing water. They are the oldest and most lasting of pigments. Samples have been found in Pompeii; they were known in Greece, possibly in old Egypt.* Their special value is in tinting, the best ochres, well ground and washed, having the brightest of durable tints, in yellow especially; *i. e.*, speaking with a view to cost and durability. Said Bouvier: "No other color can take the place of yellow ochre." There is, however, a great difference in quality of even French ochres, the lower grades containing more clay and being, perhaps, less desirable (on this account) than some American ochres. In general, ochres contain less than 40 per cent. of oxide of iron.

A well-known yellow ochre found at St. Georges sur les Prés (France) is composed as follows:

Clay	69.5	per cent
Oxide of iron	23.5	" "
Water	7.0	" "

The burned ochres change to a variety of hues; those containing more iron changing to a reddish brown; those containing more manganese, to a chestnut brown. Therefore the darker ochres dry better. The change is due to a loss of the water and to the linking of oxygen with the metal (in place of the water), especially so in the case of the manganese. The ochres are permanent to a great and last-

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* The four pigments used by the Greeks in their pictures are said (Pliny) to have been white, yellow Athenian ochre, red ochre from Sinope, and black. This corresponds very closely with the palette used by Titian (chief of all colorists) for his dead color. He knew that his red was an ochre, and, therefore, the yellow was also an ochre for harmony.

ing degree; but still the light blackens yellow ochres somewhat.

The adulteration of ochres and of all mixed and more common pigments is an important factor. Lime injures their covering power, as does barytes, for the reasons given above. Clay gives the pigment a softer and less gritty touch; but clays are affected by water, unless, as they do, they soak up quantities of oil. It will be necessary to speak of tests at another time.

Finger Test for Fineness.—All the above pigments, however, may be tested as to their fineness between the fingers, or by rubbing them upon a stone with a knife. All gritty particles and large pieces indicate a badly washed pigment. Fineness of particles is a very important quality.

Terra di Sienna.—The true article is a valuable pigment, brighter and more transparent than ochres; raw, it has "a yellow-brown hue, producing with white bright, sunny tints;" burnt, it becomes a rich orange russet, more transparent on drying. It is an iron clay, and its superiority of color may be due to a small quantity of sulphuric acid in its composition. The native American sienna is entirely inferior.

The raw sienna requires 33 per cent. of oil to prepare for market; the burnt sienna, 25 per cent.; therefore, it needs turpentine only, and will bear much thinning with it. So thinned it dries well.

Umber.—Much said of the ochres will apply to umber, which is a manganese ochre from the island of Cyprus; there is also an American article. The Cyprus umber is a soft brown color, "lovely raw umber"

(Samuel Palmer), "one of the most delicate of all the earths" (Hamerton), but with white, burnt umber gives muddy tints. "The white seems to reveal in them (umber and Vandyke brown) possibilities of disagreeableness which were unsuspected when they were alone. Vandyke brown and white look like a mixture of chalk, mud and the lees of wine; they bear no apparent relation to the fine, deep, semi-transparent brown color which bears the name of the illustrious artists." Burnt umber and Van Dyke brown, however, are useful house tints; but with white lead theircolors become spotty by the powdering and washing of the carbonic-acid lead. A little burnt umber with white lead grows *lighter* with age; more gives a continually *darkening* tint, partly due to soap-making. By itself it has a good body, and stands perfectly.

White Lead.—White lead owes its great usefulness to its density and its relations to the oil. Weight for weight zinc white may cover as well as white lead; but three coats of lead are equal to at least five of zinc. White lead should, for this and other reasons, be mixed thinner and zinc thicker than is the custom. First-grade lead from well-established houses is usually pure; second-grade lead may contain one-half barytes, and third grade be composed entirely of zinc white, barytes, sulphate of lead, lime or chalk, etc.

Adulterations.—Second-class white leads are frequently met with containing from 10 to 50 per cent. of white lead, the remainder being zinc white, sulphate of lead (which is white but has little covering power), chalk, whitening, gypsum, barytes, clay, etc.

A third-class white lead may be represented by the following sample :*

Lime	14 per cent.
Zinc white	60 "
Barytes	20 "
Other substances in small quantity	..
	100 per cent.

This "lead" was probably made by grinding together 25 parts of barytes, 15 parts of whitening and 60 parts of zinc.

Lime is the most injurious and dishonest adulteration because it turns the dried oil paint yellow. Besides, it greatly lessens the covering power of lead, as do also sulphate of lead (white), barytes and zinc white. Zinc white contains, in its cheaper forms, sulphuric acid, which may blacken the lead and otherwise injure it.

Test in oil is difficult ; in powder less so.

In Powder.—Weigh a small quantity of lead and heat it red hot ; the carbonic acid is driven off with a loss in weight on an average of 14 grains in every hundred. As much as 16, or as little as 13 grains may be lost in weight ; but if very much more or very much less than these amounts the lead is probably adulterated.

Test No. 1.—Any white paint ground in oil may be tested by comparison with a pure article. Weigh out 100 grains of each paint to be compared, add three drops of linseed oil to each and spread with a steel spatula (or knife) on sheets of glass 6 × 12, as nearly as possible in the same manner. Place the samples (thus prepared) between yourself and the light, and

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* Debrunner.

looking through them, you will have no difficulty in deciding which is the most opaque, and therefore will cover best, and is (probably) the purest lead. The sample which appears darkest and shuts off most light has the greatest covering capacity.

Chandler's Test.—Use 100 grains of white lead ground in oil, ½ grain lamp black (best), 4 drops of boiled oil. Mix thoroughly on a glass plate with a steel knife, and you will have the materials for a "quantitative" test :

Paint the mixture on a surface, the resulting color tests the purity of the lead.

White lead mixed as above.			With barytes in oil.	Color produced.
100	grains	and	0 grains	Light drab.
95	"	"	5 ‘	Slightly darker drab.
90	"	"	10 "	"
66⅔	"	"	33⅓ "	"
50	"	"	50 "	"
00 lamp black ½ gr.			100 "	Black.

"On trial, six different persons agreed separately to the differences in color as given above." (Prof. C. F. Chandler). If zinc white be in the lead, the color produced by the mixture will tend to bluish drab in proportion to the amount of zinc ; 6 or 7 per cent. of zinc is sufficient to give a decidedly bluish tint. On the other hand, mixture with barytes gave a pure drab, darker in proportion as adulterated with barytes.

The practical painter will have no difficulty in applying this test with sufficient accuracy, if he will weigh out in ordinary scales, say 100 ounces (6½ lbs.) of each sample to be compared, adding to each half an ounce of dry lamp black, and to each sample an equal quantity of boiled linseed oil. After mixing the lead, black and oil together, *very thoroughly*, spread each sample on glass, wood, or other smooth surface as nearly alike as possible, when the difference in depth of color produced by the black will determine the comparative value (or covering power) of each sample.

The sample most discolored will have the least body, and that least discolored the most body. (Prof. C. F. C.)

White Lead.—The table on the following pages may assist those who desire to discover what adulteration has been used in lead or other white paint.

NAME OF THE PIGMENT.	CONDUCT TOWARD		Heated before the blow-pipe.	Special properties.
	Muriatic acid.	Caustic soda.		
1. Whiting (precip. chalk, Vienna chalk, Blanc de Troyes, Blanc de Mendon), calcium carbonate.	Soluble with effervescence.	Unchanged.	Becomes incandescent and turns turmeric paper brown after cooling.	Not poisonous.
2. White lead (ceruse, pearl white, Hamburg white, Venice white, etc.), carbonate of lead, etc.	Soluble with effervescence and deposition of small crystals.	Soluble without residue (80 per ct. when bad.)	A coating formed on the charcoal, citron-yellow when hot, sulphur-yellow when cold; easily fusible metallic beads also formed.	Blackened by sulphureted hydrogen. Poisonous.
3. Pattison white lead, lead oxychloride.	Soluble *without* effervescence. Deposition of small crystals.	Same as above.	Same as above.	Same as above.
4. Zinc white, zinc oxide.	Soluble. No effervescence.	Soluble without residue.	Yellow while hot, white when cold.	Fused with cobalt nitrate solution turns green. Somewhat poisonous.
5. Antimony white, antimonious acid.	Same.	Same.	White, easily volatile coating, metallic globules which give off white smoke.	Poisonous.

Name of the Pigment.	Conduct toward		Heated before the blow-pipe.	Special properties.
	Muriatic acid.	Caustic soda.		
6. Bone ash, carbonate and phosphate of calcium.	Soluble after heating effervescent at first.	Unchanged.	Unchanged, but becomes incandescent.	Not poisonous.
7. Baryta white (blanc fixe, mineral white), sulphate of barium.	Unchanged.	Same.	After igniting, if moistened with muriatic acid gives odor of sulphureted hydrogen.	Very heavy. Not poisonous.
8. Gypsum (alabaster), hydrated sulphate of calcium.	Same.	Same.	Incandescent, otherwise, like heavy spar; gives water if heated in a tube.	Difficultly soluble in water. The solution is rendered turbid by chloride of barium solution. Not poisonous.
9. Clay (china clay, etc.).	Same.	Same.	Same.	Clay, moistened with cobalt solution and heated before blow-pipe, colored blue. Talc has a soapy feeling, is scaly in structure. Neither is poisonous.

CHAPTER VI.

PRIMING WOOD.

Hartig has estimated the room occupied by green wood to be as follows, per 1,000 parts :

	Fibre-stuff.	Water.	Air.
Hard green wood	441	247	312
Soft " "	279	317	404
Evergreen "	270	335	395
Average	330	300	370

A certain amount of water (7 or 8 per cent. of all) is included with the fibre-stuff. This shows us that about one-third only of the mass of the wood is solid stuff ; the remainder is either water or air space.

When we dry out the water from the wood it shrinks (see tables on page 8), contracting about 0.1 per cent. in length and 5 per cent. in breadth, or 10 per cent. on the line of yearly rings. As we have already shown, this contraction is usually a matter of no great consequence to the painter except as pulling out into view edges of surface which may not have been painted. The important thing for the painter is to keep out the water after it has once been removed, because if the water gets in again it will (1) expand the wood and crack the paint, with the grain ; (2) it will rot the wood under the paint.

If the contraction of the wood is a matter of no great consequence to the painter, however, the presence of moisture in its cells is a matter of the greatest consequence. *Why?*

As is well known, wood is composed of cells like those shown in the accompanying illustration. These cells are made of wood-stuff, which is not a solid mass, but itself composed of minute particles. Water separates these particles from each other and softens the stuff. Only in water-softened wood can the little plants which cause the dry rot get a foothold; they apparently feed on the minute particles of the fibre-stuff which have been softened in water.* Now the union between the particles of wood fibre and of the oil in paint is not a chemical one; there is no linking together, only sticking together of particles. Water does not to any degree affect paint, but it softens the particles of wood and the paint loses its grip on them.

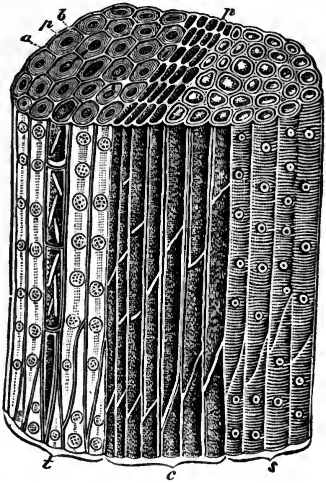

FIG. 1.

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* Cellulose, of which wood, especially the outside of the fibres, is largely composed, is much like starch, from which it is made and into which it can be changed. Cellulose, starch and sugar are all dissolved by water in increasing quantity, sugar being, in fact, the circulating form of cellulose.

It is the same principle applied to the minute particles of the wood which we work upon when we steam wood in order to bend it.

Steaming wood will not, however, bend it, nor will mere wetting peel off paint; we must have a force. This force is steam generated in the wood by the heat of the sun or other heat rays.

If any one desires to prove these statements, place an end of a painted stick in water, the end surface, of course, not being covered with paint. After a time make an attempt to peel off the paint at both this wet end and the dry end with a sharp knife. The result will show how much the wood immediately under the paint has softened, and how much the paint has already lost its hold.

A piece of spoke peeled in this way (the paint coming away almost of itself) shows by the ridges on its surface (the surface attached to the wood) what its attachments have been. One needs for the study a good microscope, with a variety of eye-pieces and lenses of considerable power. The lower powers will show long lines of ridges corresponding with the valleys between two fibres. These are strongly marked; much less strongly marked are other very slight ridges crossing the surface of the paint, and corresponding to lines between, or on, the short medullary rays (c. c. fig. 2). With more powerful glasses, and looking deeper into the surface of the paint, molds of individual wood cells (c. c. fig. 1) are seen, and the imprint of their surface. All these lines and ridges tend in one direction (except those corresponding to the medullary rays), and this direction is *with* the grain of the wood. Any strain or movement of particles will, therefore, tend to accumulate on this line, which will open cracks across the grain. The attachment to the paint is to the particles of the wood-stuff, as is shown by the adherence of certain portions after the paint has been soaked off. It is also held fast by being jammed into such valleys as we have described; but since oil contracts in drying, this hold is only occasionally a strong one.

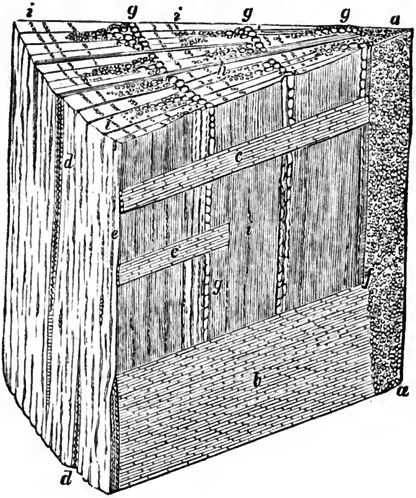


FIG. 2.

To protect the paint we must protect the wood particles to which it is attached. We can best do this by filling the cells to which the wood holds; a thin oil will soak their surface, but it is difficult to fill them. I have accomplished it with varnish, subjecting the surface to very strong heat for many days. The varnish does not then soak loose because the water does not reach the particles on the wood surface, to which the surface of varnish holds.

Priming.—The object of priming is to prevent the surface cells of the wood from being softened by water, or to protect the surface cells of wood *immediately under the paint* from water coming at them from below. For this reason a priming coat should be thin enough to enter *into* the fibre-*stuff*, and surround those particles on the immediate surface. Priming is usually not a question of soaking wood cells, but of soaking wood-cell stuff. A primer must be a thin oil which will physically combine with the wood-cell stuff.

It must not be made thin with turpentine, because turpentine evaporates, and we desire an oil which will stay, in order to protect the fibre from water; and raw linseed oil unmixed with anything will serve. A little drier in hasty work is, however, allowable; but it must give a thin oil.

In case the wood is wet, we must heat the oil—not hotter than 150°. Linseed oil at 45° of temperature is not so fluid as water, but at 79° it is more fluid. The figures are as follows:

Linseed oil. Temperature.	Degree of fluidity. Water = 100.0
45°	86.5
79°	102.2

Or, to put the matter in another way, if linseed oil at 45° temperature requires 104 seconds to flow through a given aperture, it will flow through in 84 seconds if heated to 79°.

Drying oil remains at that point in the surface where it drys; but not-drying oil (as some primers) not improbably continues to sink into the wood until it finally disappears. Some painters who have used patent primers of some kinds assert that they result in a re-appearance of the grain of the wood after finish. Others make no such complaint—facts must decide in each case.

Peeling off from Primer.—It is, however, not merely necessary that a primer be used which will penetrate the wood, but that the substance used shall be one which will readily unite with linseed oil, and to which linseed oil will stick. For this reason there is probably no better primer than linseed oil, not mixed with anything whatever.

CHAPTER VII.

OILS.

A LITTLE DICTIONARY. *Oxygen.*—One-fifth part of the air; the burning, rusting, change-producing element of the air. We breathe oxygen; get fire and light by causing it to unite with wood and coal; it rusts our iron (the iron in our blood), and we live by it; it rusts our iron bridges, and we die by them; we "dry" our oils and burn our oils by oxygen. There is no substance of whose effects we know more by *experience.*

Carbonic Acid.—The little and heavy gas of air. The product of decay, it produces decay in all living things which do not destroy it; not immediately, but by shutting out oxygen. Living plants change it into starch, starch becomes oil, oil changes again into carbonic acid and water. Carbonic acid destroys lifeless plants (trees and wood) rapidly. Iron rusts quickly in carbonic acid with oxygen. White lead is the rust of carbonic acid and lead. It is a fact of daily experience. *It is only the names of these things with which the painter is not familiar.*

Glycerine—To be had of your druggist. It is made from oils and fats.

Glycerine Ether.—Glycerine as it exists in oils, united with an oil acid.

Oil Acid.—An acid which when linked with glycerine ether is known as an oil.

Oil.—An oil acid linked with glycerine ether, and from which glycerine and soap can be made.

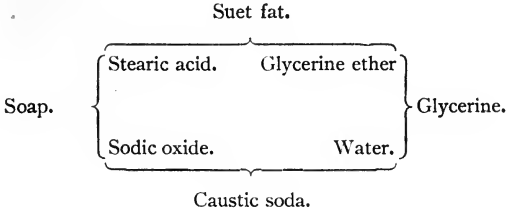
Soap.—An oil acid linked with soda, potash, lead, zinc, iron or some such substance. Some soaps do not dissolve in water.

Free Oil Acid.—An oil acid unlinked from glycerine ether, but not united with another substance.

Flying Oil Acid.—An oil acid which becomes lighter than air (due to action of heat or light) and flies away as would a gas.

Oils are useful in painting because water has little or no influence upon them. They are valuable to the artistic painter because there is less difference between the shades and colors of dry and wet paints mixed with oil than between dry and wet water colors.

What is an oil? We discover the answer on making it into a soap.



To those who have never studied chemical formulæ the above may look perplexing, but it will soon become simple after a little attention to the unfamiliar words. Beginning at the bottom of the diagram we see that caustic soda is used to put with oil to form a soap ; and that caustic soda has two parts, which are linked together, namely, sodic oxide and water. In making this soap suet fat, or, as it is called, stearine, has been used. It also is composed of parts linked together, namely, stearic acid and glycerine ether. From the mixture of suet fat and caustic soda soap results, which, again, is composed of two parts linked, namely, stearic acid and sodic oxide.

But another substance, glycerine, is also formed of the glycerine ether, which belonged to the suet fat, and of water, which was with the caustic soda.

Oils—that is to say, those oils of which linseed oil is one—are composed of an oil or fat *acid* linked with water-free glycerine—and in making any kind of soap the glycerine is set free, leaving the acid by itself or linked with something else.

Fish oil is largely

$$\overbrace{\text{Oleic acid.} \qquad\qquad\qquad \text{Glycerine ether.}}^{\text{Olein.}}$$

Palm oil, which is used in making fine soaps, is

$$\overbrace{\text{Palmitic acid.} \qquad\qquad\qquad \text{Glycerine ether.}}^{\text{Palmitin.}}$$

Linseed oil is a mixture of

$$\overbrace{\text{Linseed oil acid.} \qquad\qquad\qquad \text{Glycerine ether.}}^{\text{Linolein.}}$$

and of olein and palmitin.

In linseed oil there are 80 parts of linolein (linseed oil acid, glycerine ether), 20 parts palmitin (palmitic acid, glycerine ether) and olein, etc. (oleic acid, glycerine ether).

Soap.—Clear ideas about soap will be very useful in studying oils and paints. Hard soap is made of oil acids and soda, soft soap of oil acids and potash. In making soap, the potash or soda is dissolved in water ; and this water remains in the soft soap, while from hard soaps it is drawn off, carrying with it the glycerine which was united with oil acid before the soda or the potash displaced it and left it free to unite with the water. The following is an analysis of several kinds of soaps. Some soaps contain also 2 or 3 per cent. of glycerine :

TABLE NO. I.

	Oil acid.	Potash.	Soda.	Water.
Marbled soap (tallow)	81.25	1.77	8.55	8.43
Castile soap	76.50	....	9.00	14.50
Palm oil (yellow)	65.20	....	9.80	19.90
Soft soap (common)	42.80	9.11	....	48.00
" (white)	45.	8.50	....	46.50

It will be seen that the oil acid, the potash and soda and the water vary in several soaps. The soap is valuable in proportion to the amount of oil acid it contains, *i. e.*, when the soap is to be used for toilet purposes *free* soda or potash and too much of either united with oil acids injure the skin.* In washing one's hands, soap removes the grease and greasy dirt which water alone will not dissolve, because water has little influence upon oils. Part of the soda of the soap unites with the dirty oil acids, changing them also into somewhat of a soap, which is easily dissolved in water. The other part of the soda remains united with the oil acids of the toilet soaps, and forms a lather useful by inclosing and carrying away all particles of dirt, especially greasy dirt, which have or have not been changed by the action of the soda. The action of soap, therefore, is partly chemical (the union of the soda with the grease) and partly mechanical (the removal of dirt by the lather). It is the same kind of action which removes the varnish from a carriage or a car when strong soap is used to wash it.

It requires time for the oil acid to unite with the soda either in soap making or in hand washing. If a little of the soda unites with the oil acid, there is a weak soap; if more, a strong soap; in each case, however, the soda has taken the place of the glycerine ether which was united with the oil acid. The glycerine ether has been unlinked from the oil acid and set free. Glycerile unites with water and be-

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*The Pennsylvania Railroad had their attention called to soap by the destruction of the varnish on a car by a washing with soap. Dr. Dudley, their chemist, looked into the matter, and all soap purchased is required to contain less than ¼ of 1 per cent. of alkali carbonates.

comes glycerine, which mixes readily with the remaining water.

Lime soaps and lead soaps do not dissolve in water, and by making a lead soap by uniting oil with litharge, it is easy to get the glycerine from the water, because the lead soap falls to the bottom of the vessel, and leaves the glycerine in the water, from which it may be obtained by evaporating the water. If pure glycerine be desired, some sulphur gas (sulphuretted hydrogen) may first be passed through the water and glycerine that any lead dissolved in the water may fall to the bottom. The sulphur in this gas unites with the lead and forms a heavy black powder—a sulphide of lead, the same substance which is found when white lead turns gray (not yellow) after it has been exposed for some time to air. The air of cities, especially, contains more or less sulphur gas.

Oil Acids.—It is plain that oil acids may exist in three states: (1) linked with glycerine ether, thus forming *oils;* (2) linked with such substances as potash, soda, lime, lead, iron, zinc, magnesia, or manganese, forming *soaps;* (3) unlinked and free—*i. e.*, chemically free—from glycerile or soap-making substances, or, in other words, as *free oil acids.* In proportion as oil acids are free do they tend to form soaps when mixed with soap-making substances. Oils—*i. e.*, oil acids linked with glycerine ether—may be mixed with soap-making substances without forming soaps. If two kinds of oils are mixed, one oil may more readily change into soap than the other, when to the mixture is added a soap-making substance. The oil acids may change otherwise than by becoming soaps. They may become *rancid*, or they may *dry.*

CHAPTER VIII.

THE DRYING OF OILS, AND THE DRYING OILS.

All oils tend to change in the air; those less pure changing most rapidly. Butter which has not been properly freed from buttermilk is a good example.

This change is, first, the unlinking of the oil acid and the glycerine, setting the oil acid free. Still, exposed to the air, the oil may give a sharp, unpleasant odor and taste due to further changes; it has become rancid. Rancid butter may be sweetened, however, by washing it with some substance which will form a soap with these rancid acids and remove them. Lime water is sometimes used for this purpose; and the clearing up of a fatty linseed oil by litharge is an action of the same nature. In this case a lead soap is formed by the acid and the litharge.

The drying part of the linseed oil—*i. e.*, linolein (linseed oil acid and glycerine ether) does not become rancid. The same is true of the drying portion of poppy oil and of other drying oils. The drying parts of these oils thicken and change into sticky, elastic, or into leather-like substances, all of which are waterproof, and upon all of which water has only a small influence.

The Changes in Oils.—The chemical changes in oils which become rancid and in oils which "dry" are of the same nature; the results are different because the oils are different.

The science of chemistry is founded upon weight. If a substance changes and weighs heavier than before the chemist is sure it has gained something. If a substance changes and weighs less, he is sure that it has lost something. He then proceeds to discover what it is that has been gained or lost, and in this his scales are again useful in weighing other substances with which this one has been in contact, in order to discover which of them has taken the lost something, or has given up the something gained.

Linseed oil in drying gains from 8 per cent. to 10 per cent. in weight. A French chemist exposed some drying oil to the air. It weighed about 155 grains; after eighteen months, about 166 grains. It had gained about 11 grains, or more than 6 per cent. of its weight. In speaking of the drying of linseed oil, therefore, we mean merely a change from a fluid to a solid condition. There is a loss of something, as we shall see, but there is a gain which not only makes up in weight for this loss, but usually leaves the same quantity of linseed oil 10 per cent. heavier than before it became "dry."

The Influence of Darkness, Light and Colored Light on Drying Oils.—A Dutch chemist, who has made a careful study of the drying of oils, arrived at the conclusion that linseed oil increases in weight in exact proportion to its becoming dry.* Without entering as yet into the question what it is that increases the weight of dried oil, we can study its drying by comparing simply its weight. Any one may do this by comparing the following groups of figures with each other. We shall leave them in that measure of

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* Not absolutely but practically so, under the same conditions.

weight which the chemist uses, namely, grammes. A gramme is 15.432 grains.

TABLE NO. 2.

Gained in Weight as Below.

OIL DRYING AFTER.	In darkness	Under uncolored glass.	Under red glass.	Under green glass.	Under blue glass.	Under yellow glass.
Days.						
10	0.000	0.126	0.009	0.005	0.089	0.012
20	**.001**	**.258**	**.027**	**.023**	**.245**	**.041**
30	.002	.317	.048	.076	.332	.103
40	.003	.326	.082	.139	.376	.184
60	.007	.298	.178	.269	.388	.319
80	.013	.272	.284	.354	.370	.388
100	.018	.261	.338	.401	.357	.417
120	.024	.273	.376	.438	.360	.442
150	**.035**	**.300**	**.441**	**.485**	**.399**	**.474**

Comparison of the increase by weight of the drying oil under the several glasses gives the order of drying as follows: Most rapid under the uncolored glass, then follow blue, yellow, red and green, but this order is of no consequence, nor trustworthy as a constant fact*.

After 150 days, on the contrary, the gain in weight is greatest in the following order, under green, yellow, red, blue and uncolored glass.

In darkness there is no drying, or it proceeds so slowly that it may be said not to go on at all. *Light is the first natural drier of oil.*

There is another experiment by a more accurate chemist, in which the gain and loss in the weight of the drying oil are given day by day. The oil was spread

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* See Changes in Pigments due to Sunlight.

upon surfaces, one exposed to the sunlight, the other remaining in half darkness. The measure of weight is in grammes and decimals of a gramme, as before.

TABLE NO. 3.

Oil Drying.

Date.	In sunlight. Grammes.	In half darkness. Grammes.
April 29......	...6.860	7.802
April 30, g'd..	.03	Nothing.
May 2, " ..	.174	.004
" 3, ' ..	.226	.004
" 4, " ..	.044—0.474 in 6 days.	Nothing.—0.008 in 6 days.
" 9, " ..	.034	.034
" 14, lost..	.041	Gained..180
" 20, " ..	.030	" .378
" 28, g'd..	.026	" .220
June 4, "	.024	" .012
" 11, lost..	.043	Lost..028
" 18, " ..	.014	" ..006
July 26, g'd..	.085	Gained..033
Aug. 19, " ..	014	Lost..003
Total gain..	657	.865
Total loss...	.128	.037
	.529 gain.	.828 gain.

The powerful influence of light upon the drying oil is shown in the plainest figures by these two tables. They indicate that a painting or varnishing shop should have many windows, and a great abundance of uncolored light—no sort of driers in a shop are more valuable than windows.

These tables also show that oil loses as well as gains something in drying, and that the least loss or greatest gain after many days is in slowly drying oil.

Influence of Heat.—The following table shows the influence of heat upon drying oil:

The applied oil was kept in a room having a temperature about equal to that of the Eastern States in the latter part of May and the early part of June (from 59° to 68° F.). One of the oiled panels was subjected to a considerable heat for several hours each day (a heat of 176° F.).*

TABLE NO 4.

Oil Drying.

The panel not heated weighed		2.466	grammes.
The heated panel weighed		1.934	"
1st day—While heated for 2 hours	gain	.018	
After heating	"	.072	
		.090	
Panel not heated	"	.002	
2d day—While heated for 4 hours	gain	.056	
After heating	"	.065	
		.121	
Panel not heated	"	.002	
4th day—While heated for 6 hours		.032	lost.
After heating	gain	.013	
Total		.019	lost.
Panel not heated	gain	.003	
5th day—While heated for 7 hours		.052	lost.
After heating	gain	.017	
Total		.035	lost.
Panel not heated	gain	.002	

The panel which was heated but two hours the first day and four hours the second day—

	Gained	.211
Panel not heated	"	.004

In other words, heating the panel dried it about fifty times faster than it would otherwise have dried, and that in a mild atmosphere. Every painting and varnishing shop should be well furnished with steam-heat-

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* There are two kinds of thermometers. (1) *Centigrade*, used by chemists and in Europe ; (2) *Fahrenheit*, used in this country and in England. " F." means the latter ; " C." means the former. The difference between the two is in the scale used to mark the degrees.

ing apparatus, or, if this is not possible, with a number of stoves. As stoves are usually placed, one side of a painted or varnished car or carriage dries more rapidly than another; there is need of heat on all painted sides.

The heat, however, must not be too great, and especially should it not be moist heat. A heat above 176° is probably injurious to good drying, but a less heat than this may injure the varnish or oil by driving it into the coats beneath or into the wood. This will be no injury to the wood (as we have seen), nor to the drying of the oil, but will tend to leave the "gums" of the varnish on the surface. The temperature of a varnish room is usually 70° to 90°.

The Gain in Weight of Drying Oil.—We have seen that oil in darkness hardly increases at all in weight. In the light, and especially if heated, drying oil becomes from 8 per cent. to 10 per cent. heavier. Does it get this weight from the rays of light?

Science has shown that these rays have no weight, that both light and heat are merely waves of motion, like the waves which spread over the surface of smooth water when we throw a stone into it. The water is no heavier for the motion, it is only heavier because of the stone. Air, however, has weight as a stone has; 100 cubic inches weigh 31 grains; the air presses upon us on all sides, because it is heavy, so that a man's body sustains 37,560 pounds, or upward of 16 tons, of pressure from the air.

Air, however, is not a simple substance; it is composed of at least three gases, nitrogen, oxygen and carbonic acid.

These are not linked together, but simply mixed together as shot, peas and potatoes might be mixed ; so that while the names of these gases may be unfamiliar, every one is constantly familiar with the gases themselves. We breathe into our lungs the nitrogen and oxygen (mixed).

Air is nitrogen gas and oxygen gas mixed, 4 of N to 1 of O in every puff of pure air :

NONNN
NNNNO

Air from the lungs would contain all the " Ns," one less " O " in every 5 " Os," and a little C, or carbonic acid, the heavy gas which causes clear lime water to turn white and milky on blowing one's breath into it. Every breath *into* the lungs contains 80 parts of nitrogen and 20 parts of oxygen.

The air breathed *from* the lungs contains all the nitrogen (80 parts), but only 16 of the 20 parts of oxygen, and from 2 to 5 parts of carbonic acid. The other 4 parts of oxygen we keep.

It is with the air as with some other things : We have had a large experience in it. We need only a little definite knowledge about it.

Chevreul, a great French chemist, made the following experiment in order to prove which of the gases of the air unite with the drying oil. He painted four panels alike, one side of each with white lead, the other side with zinc white, both prepared with linseed oil. No. 1 was placed in a closed glass box containing carbonic acid. No. 2 in a glass box containing air. No. 3 was left exposed to the free air, and

No. 4 was placed in contact with oxygen gas. The following table gives the results :

TABLE NO. 5.

		After 24 hours.	After 72 hours.
No. 1. Carbonic acid.		The white lead nearly set,	but without adherence to the wood.
		The zinc white	absolutely fresh.
No. 2. Limited air.		The white lead nearly dry.	Perfectly dry.
		Zinc white set but not dry.	" "
No. 3. Free air.		White lead nearly dry.	" "
		Zinc white set but not dry.	" "
No. 4. Oxygen gas.		The white lead perfectly dry	
		Zinc white " "	

Another French chemist analyzed oil before and after its drying. He found :*

Before drying	11	parts oxygen gas.
After "	22	" " "
Gain in drying	11	parts of oxygen.

Otherwise there was little change in its elements, except a slight loss of carbon and hydrogen. As a rule, drying oil adds probably one-tenth to its weight by taking up oxygen from the atmosphere. It may add, however, even more, since there is no exact measure of the loss which is going on at the same time.

What does Oil Lose in Drying?—Reference to tables No. 1, 2 and 3 will show that oil loses in weight, as well as gains in weight, while drying, and that this loss is least in slowly drying oil.

The comprehension of the process of this loss of weight will carry with it a better comprehension of the whole subject of drying oils.

Black oxide of iron (black scale) and red oxide (red rust) seem quite unlike, yet they are both a union

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* The analysis, as we shall see, is not a close one.

of iron with oxygen gas. In the same manner, different substances result from the union of oil with the oxygen of the air.

We have already seen that linseed oil is composed of

Linolein.
Linseed oil acid. Glycerine ether.
Palmitin.
Palmitic acid. Glycerine ether.
Olein.
Oleic acid. Glycerine ether.

Part of the loss in weight of the oil comes from the loss of the palmitin and the olein, the latter especially. When considerable oxygen unites with the oleic acid, a substance results which quickly flies away. When less oxygen unites with the olein, a more solid substance results which does not so quickly fly away. Nevertheless, by heating the dried oil, we can drive it off from the still more solid dried linolein.

As shown in table No. 3 (comparison of oil dried in sunlight and in darkness, page 63) oil dried in darkness gained the most.

Gain in sunlight.	Gain in darkness.
0.529 grammes.	0.628 grammes.
Heated to 176 degrees there were	
0.106 grs. lost,	.235 grs. lost,

respectively, that in darkness losing at least one-half more than that oil dried in sunlight.

Slowly-dried oil, therefore, contains more of the non-drying fats, and for this reason seems to gain (after a long time) more in weight. In table No. 2, (page 62), the quickly-drying oil weighed after 150 days 0.300, and the slowly-drying oil (under green glass) 0.485 grammes.

In the same way (by differences in drying) the drying portion of the oil (the linolein) produces different substances, as we shall see.

The Glycerine Ether.—There is also another and still more important loss of weight in drying oil. If we are so fortunate as to go to bed by the light of a tallow candle, we will observe a peculiar and sickening odor on putting out the flame and leaving the wick to smolder.

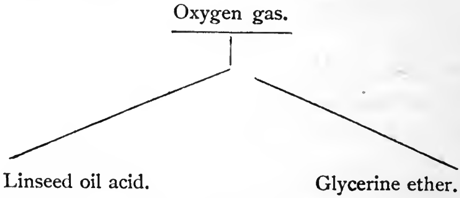
A tallow* candle is largely

$$\overbrace{\text{Stearic acid.}\qquad\qquad\qquad\text{Glycerine ether.}}^{\text{Stearine.}}$$

By the heat, some of the glycerine is unlinked from the fat acid and changed into the unpleasant, sickening substance which our nose discovers to be in the air.

It is the same with the changes in both the not-drying and the drying parts of oil. The glycerine ether is unlinked from the fat acid and flies away. A heat of 176°—much less heat than will boil water—begins to drive off the glycerine ether from the drying oil.

The process of drying appears (1) to begin with the unloosing (not unlinking) of the glycerine from the oil acid, thus:



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* Composite candles are made without glycerine, and give no such odor.

And at this point the oxygen of the air begins to unite with the oil acid to form a varnish.*

The whole process of drying appears to be the linking together of oxygen with the oil acid, and therefore plenty of pure air is absolutely necessary to dry paint and varnish.

The ventilation of a painting shop in order to get as much pure, warm air as possible without dust is a matter of the *first* importance. Abundance of light is of nearly equal importance, as we have seen. Before drying, the oil is a fluid, water-like acid, the oxygen an invisible gas filling a large amount of space. After the drying, both appear together as a thin, solid, elastic varnish.

Review of the Drying of Oil.—Although our knowledge of the drying of oil is still not complete, we may profitably take a review of what we have already learned.

(1). Linseed oil is composed of

Drying oil	80 parts
Not-drying oil	20 "
	100 "

of which 8 parts are glycerine ether.

(2). Pure oil will not dry in darkness, light is necessary; and the greater the light, the more vigorous the drying.

(3). Heat is also a powerful drier of oils. Oil heated for a short time continues to dry more rapidly for hours after the heating.

(4). "Drying" appears to be the loss of glycerine

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* This is an explanation by facts—for theory, see Theory of Linseed Oil, Part II.

ether and the gain of oxygen from the air. The glycerine appears to be *unloosed* from the oil acid, as the oxygen unites with the oil. The result of the drying is a bright, hard and elastic varnish.

(5). Much of the glycerine ether which is linked with the oil acid flies away in the drying.

(6). Some of the not-drying oil acid also flies away in drying—especially under the influence of the direct sunlight, or when the oil is heated.

100 parts of oil become	111 parts (more or less)		
Heated, it loses	3	"	"
Net gain	8 parts	"	"

THE DRYING OILS

Lin(flax)seed oil freezes at -	18.4°	F.below	zero
Poppy seed oil freezes at -	1.5°	"	"
Walnut oil freezes at - - -	18.4°	"	..
Prunella (a Japanese oil).			
Hempseed oil freezes at -	18.4°	"	"
Castor oil freezes at - -	1°	'	"
Sunflower seed oil freezes at - -	3.6°	above	"
Grape seed oil freezes at - -	1°	"	"
Cotton seed oil freezes at - -	28°	"	"
Fish oils freeze at - - -	30°	"	"

Oils are made solid by cold, and become less in volume; in other words, they *contract* and solidify, and this is what is meant by the "freezing." One thousand and sixteen quarts of olive oil in summer (about 70°) become in winter only one thousand quarts (at 32°). Those oils becoming solid at highest temperatures are most unfit for use in paint; but results differ as to exact points, and the figures given in our table are all low points—some samples would become solid at higher temperatures.

Some of the above are more properly half-drying oils. Linseed oil stands first in every good quality, except for its tendency to change color.

Of the family of flaxworts, there are several of this country; but the common flax plant* belongs to those old countries where men first lived; and in all historical times has been a cultivated plant.

The flax plant, like all others, is a chemical laboratory, the working-rooms being specially the leaves. In the seed are stored up the choicest results of the chemical work: (1) plant flesh (albumen), which exists in the seed as the body of a new plant: (2) sugar, starch, ucilage, which are ready preserved foods for the young plant; (3) oil, which is concentrated or stored-up food, which may be (strange as it seems) changed into sugar or starch again before it is used. This oil is what we wish in painting; the flesh (albumen), and the starch and mucilage are what we do not want. In pressing the oil, however, we probably get all three.

Analysis of the Ripening of Olives.

Composition of pulp and fruit.	Percentages at different dates.					
	June 30.	July 30.	Aug. 30.	Sept 30.	Oct. 30.	Nov. 15.
Oil and green leaf substance.	.40	5.49	29.19	62.30.	67.21	68.57
Some other substances	98.00	94.00	52.00	27.00	22.00	†22.00
Percentage of water in total plant	22.00	60.00	61.00	56.00	51.00	50.00

As we have no analysis of the ripening of flaxseed we give that of another oil-giving seed (the olive) at various periods of its growth.

It will be seen at once that we should get more water and more substances which we do not want, and

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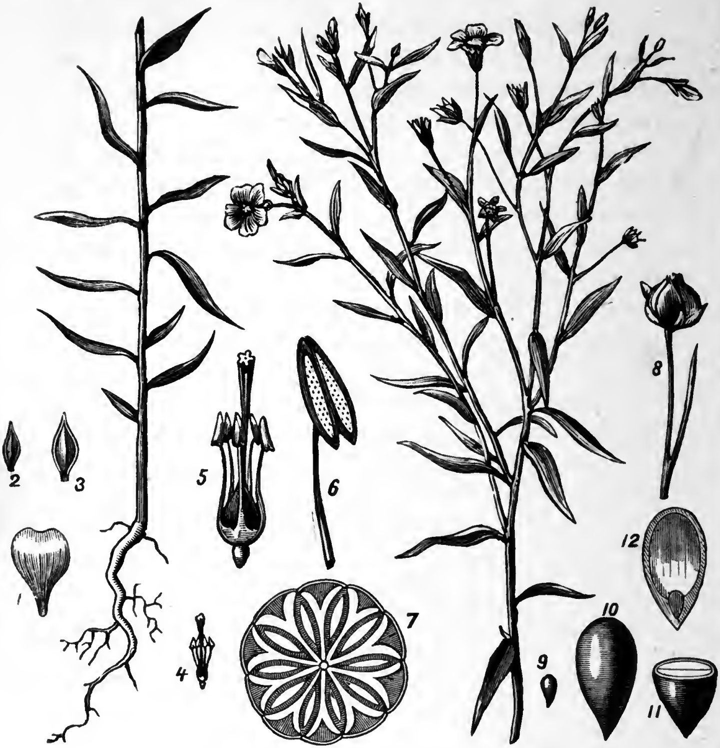
* *Linum visitatissimum.*

† These are woody substances, nitrogenous substances make up the remainder. The percentage of water is to the total plant; of the substances above the line to the total of dry plant-stuffs.



FLAX PLANT—FLOWER, SEED VESSEL AND SEED.

Its flower is blue. Fig. 1 represents a flower leaf or petal; there are five to each flower, which is of a very regular and perfect kind, having five petals, five pistils, five stamens, five sepals. Figs. 2 and 3 are sepals, or cup leaves, to the flower; figs. 4 and 5 represent the seed vessel, with its tall stamens and taller pistils; fig. 6 is a stamen; fig. 7 is a seed vessel cut open, showing 10 seeds. The stamens fertilize the pistils, the pollen falling upon the top of the pistil, or probably carried there by some busy bee. Within each of the pistils (not to speak exactly) grow two seeds, as seen in fig. 7, divided by a little wall. Fig. 8 is a ripe seed vessel. Sections of the seed and the perfect seed are seen in figs. 9, 10, 11 and 12.

also much less oil, from green seed. It is doubtful whether either the plant-flesh or the mucilage would flow out when the seed is pressed, if it were not for the contained water.

The Oil.—The process by which the oil is made in the plant is possibly as important as it is interesting to know. After years of study it is a matter of *great* uncertainty, but even out of uncertainties practical light may come.

There is reason to believe that under the influence of the sun's rays the oil is made as follows :

Under
Sunlight.

Carbonic acid (of the air)
becomes
Green leaf substance,
which becomes
Starch, yellow leaf-stuff,
which becomes
Sugar, not drying oil (palmitin),
which becomes
Oil, drying oil (linolein)

Everybody knows that grass is green, and that leaves are full of green stuff.

Everybody knows that quantities of glucose are made from the starch of Indian corn. These bits of every day knowledge are sufficient for some comprehension of how the oil is made in the laboratory of the plant.

One of the most celebrated botanists does not believe that green-leaf stuff is made from carbonic acid.

It is sufficient, however, if imperfect leaf-stuff be mixed with linseed oil.

The Mucilage.—We are soon acquainted with this pleasant slimy substance on putting some flaxseeds into the mouth, and perhaps we have also pleasant recollections of soothing flaxseed poultices. It has the peculiar property of soaking up water, and is therefore not desirable in the oil. The plant-flesh—the juices of the little crushed seed plant (see fig. 12 on page 74)—has the same influence on the oil which unremoved buttermilk has upon butter—namely, to make it rancid. It is doubtful how much of these substances are in the oil; the chances are even that the "foots" of well-settled oils consist of imperfect, unripe oil, mixed with the green-yellow plant-stuff from which it has been made.*

I am told that more of these substances exist in American seed oils than in oils from seeds imported. The Calcutta seed oil is given the preference for color, both in America and in England; and, although very little is imported, some of the white-lead manufacturers use it in grinding with the lead.

The Calcutta seed, however, has probably no advantage in the amount of mucilage it contains; examination by an English chemist showed quite as much mucilage and plant-flesh in these seeds as in others.†

The difference in oils is probably in the amount of unripe oil which they contain, which is made from and

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* Mulder found no satisfactory evidence of plant-flesh in linseed oil, although he did not deny it might be present. The stuff thrown down from the oil by sulphuric acid and acetic acid lead was apparently heavy dark oil.

† Mucilage in seeds ranges from 18 to 50 per cent.; albumen, from 17 to 25 per cent.

mixed with color-stuffs. The amount of these foots in various oils has been estimated as follows :

Linseed oil 1 1-10 parts in 100 of oil.

Poppy-seed oil and cotton-seed oil a very little more ; but all such estimates are difficult and uncertain as to what is found.

The figures are valuable as showing how troublesome may be a very small amount of imperfect matter.

The Yield of Oil.—" Heavy seed will yield most oil: and seed ripened under a hot sun, and when flax is not gathered too green, is the best. The weight of linseed varies from 48 to 52 lbs. to the imperial bushel, probably a fair average is 49 lbs., oil 7½ lbs. to the gallon—perhaps 3.60 lbs. of seed to one pound of oil." —(Woolsey in Ure's Dictionary.)

OTHER DRYING OILS.

Prunella, a Japanese oil, has recently received some attention; but little, however, is known of it.

Poppy Oil is obtained in quite large quantities from the small black seeds of the ordinary poppy plant (*papaver somniferum*), which are so rich in oil that they are capable of yielding about half their weight of it. It is clear yellow in color, but becomes solid at a higher temperature than linseed oil. In varnish manufacture it is used for producing only especially fine products, and it is also used by artists for diluting colors. Poppy oil dries faster than nut oil and slower than linseed oil. It, however, does not remain sticky so long as linseed oil. Both poppy oil and nut oil take up less oxygen in drying than linseed oil.

Mulder speaks of the use of poppy oil by artists to mix with the linseed in summer, when the latter hardens too quickly. This oil and nut oil may be made clear by mixing with water and placing in a bottle in the sunlight. The bottle must be uncorked, so that the air may act upon the oil. Poppy oil contains:

Not-drying oil	20 parts
Drying oil	80 "
	100 "

Nut Oil (*Walnut Oil*).—This oil is obtained from the nuts of the walnut tree (*juglans regia*). The cold-pressed oil is quite different from that which is obtained after heating. The former is almost colorless, or only of a weak, yellowish-green shade, and has in the fresh condition a very pleasant odor and taste; exposed to the light, it bleaches completely after a short time.

Warm pressed oil is characterized by a deep color and an odor that is not pleasant. For obtaining this oil, therefore, use is always made of hydraulic presses; these give the greatest pressure. Since the cold-pressed oil always has a higher value, it is always an object to obtain the highest pressure possible, so as to obtain the greatest yield possible by the cold process.

On account of its unusual clearness, nut oil is much used abroad for fine varnishes and for diluting colors in oil painting. Nut oil dries very slowly. Nut oil contains:

Not-drying oil	30 parts
Drying oil	70 "
	100 "

Hempseed Oil.—Hempseed oil, which is obtained by either cold or warm pressing of the hempseed (*canna-*

bis sativa), is of a clear, yellowish-green color as long as it is fresh ; old oil grows darker continually until its final color is a turbid brown. It has been largely used to adulterate seed sent to England from Russia, and perhaps from India,* and has, no doubt, affected the quality of the oil produced. *Purity of seed is a very important matter* for paint and varnish oils.

Cotton-seed Oil.—Crude cotton-seed oil is a reddish-brown oil which dries after a long time, but retains a "tach." It is not properly a drying oil. Refined cotton-seed oil is of a lighter and more transparent yellow than linseed oil.

Buyers of linseed oil should be careful to observe the relative prices of cotton-seed oil and of linseed, for any considerable differences in favor of the linseed oil will greatly increase the danger of its adulteration by this oil.

Fish Oil (*Whale Oil*, *Menhaden Oil*, *etc.*).—Fish oils dry slowly, but, nevertheless, they will dry. They are composed largely of not-drying oil. A correspondent† writes: "The oil, when applied to a tin roof, sticks longer than linseed oil, not drying so hard." It is more influenced by cold, however, than linseed oil, but mixed with driers may be a valuable adulteration of linseed for tin roofs. It is not to be recommended for wood, unless as a matter of necessary economy. Whatever is placed over it at any time as a second coat will probably crack.

Menhaden oil is the "leading" fish oil. There are three grades, all much cheaper (at least one-third)

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* Linseed imported to this country is very pure.

† Mr. B. Hammond, Mt. Kisco, N. Y. There is little doubt that this is correct.

than linseed oil; crude oil; oil with foots removed: and refined oil. The oil being made from fresh fish has much less odor than fish oils formerly. Its odor is best detected on heating the oil. Linseed oil with soda has sometimes a fishy smell, the flying oil acids of both being alike in character, not in quantity.

THE DRYING OF POPPY OIL AND NUT OIL.

The drying of poppy oil and nut oil differs from the drying of linseed oil because these oils contain more not-drying oils, and because these are of a different kind from the not-drying oils in linseed.

	Fresh poppy oil.	Old nut oil.
Sept. 3	1.438 grammes.	1.029 grammes.
" 5	gain .016 "	gain .030 "
" 6	" .059 "	" .006 "
" 7	lost .046 "	lost .014 "

And this loss continued with the exception of one or two days until Oct. 1, when each had

Lost	Total 0.099 grammes.	0.068 grammes.
Gained	" 0.086 "	0.036 "

This was a *loss* of 9-10 of 1 per cent. for the poppy oil, and of 3.1 per cent. for the nut oil. Linseed oil usually gains 8 to 12 per cent. At another time poppy oil lost 4 per cent., and nut oil over 2 per cent., the greater amount and the kind of their not-drying oil making the results of drying very uncertain. This last nut oil was, however, less old than the other.

With a Lead Drier.—When, however, poppy and nut oil were mixed with litharge, they gained, the poppy oil 7½ per cent., the nut oil over 6 per cent. Why is this? We shall see.

CHAPTER IX.

OLD OIL AND FATTY OIL.*

Some old oils dry much faster than new oils, as the following experiment by the great French chemist Chevreul will show :

TABLE NO. 6.

When spread.	Oil kept 44 days in a closed bottle.	Oil kept 44 days in a bottle with some air.	Oil exposed. 44 days to free air.
1st. coat dried in...........	11 days.	9 days.	4 days.
2d " "	8 "	8 "	5 "
3d " "	6 "	6 "	4 "
The three coats dried in..	25 days.	23 days.	13 days.

It is well known that other old oils seem to have lost the property of drying ; they become thick and "fatty," but do not dry. The well-known English artist Holman Hunt was once advised to paint with fatty oil in order to prevent cracking, and he says that picture is not dry yet. Where is this difference in oils ? We know the tendency of change in long-kept oil exposed to light and air is the unlinking of the oil acid from the glycerine, leaving the oil acid free. This is the change which takes place when oils become rancid, and also in oils which become dry. It is, therefore, important to know what would occur if this change should take place before the oil has taken up much oxygen, in other words what an oil acid un-

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* The chemical changes (in oils) now to be studied are less assuredly known. Putting aside the chemical explanation of facts attention will be fixed on certain general aspects of those which have relations with practice. Statements, must, therefore, be taken as scientific light upon practical questions ; not as absolute certainties without shade of doubt.

linked from the glycerine ether would do about drying. There are those who have reasoned that it is the glycerine ether which prevents the oil from becoming dry. One, and perhaps several, patents have been secured for processes which will unlink the glycerine ether from the oil acid. What the effect of such a process would be will be seen by the following tables, which give the increase of weight of an oil acid which had been unlinked from the glycerine by adding lead to the oil, and so making a lead soap of the oil acid and the lead. From this oil-acid-lead soap the acid was washed away with ether, the ether driven off and the oil acid, at last, left free.

TABLE NO. 7.

Drying of Free Oil Acid spread on a Surface exposed to the Light.

Gain in weight in 3 days nearly 8 per cent.
" " " 7 " about 18 per cent.

EXPERIMENT NO. 2.

Gain in weight in 3 days about 8 per cent.
" " " 7 " " 14 "
Total gain after many days....17½ "

Oil in drying gains in weight from 8 to 12 per cent., but this free oil acid gained 17 per cent.

Nevertheless, it was not dry, but sticky, "tachy," somewhat like pitch in character, not in color. It did not become dry for many months after this gain in weight. Mulder, therefore, properly says that linseed oil acid unlinked from the glycerine ether requires as many months as linseed oil requires days to dry

There are, in fact, two ways in which oil may dry.

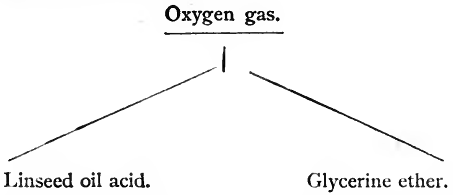
1st. It may dry directly into a hard but somewhat elastic oil leather.

2d. It may dry by becoming free from glycerine ether, then by taking up oxygen and becoming a sticky, pitch-like oxy-oil acid.

This sticky, tachy acid may finally change into not-sticky oil leather.

Quick-drying Old Oil.—As we have seen, the unlinking of the oil acid from the glycerine ether causes it to dry slowly; nevertheless, good old oil dries more rapidly than fresh oil.

A very simple explanation can be given which is true to all the facts: Whatever unloosens the oil acid from the glycerine ether causes it to dry faster; whatever unlinks the oil acids from the glycerine ether and sets the oil acid free in an atmosphere containing not enough oxygen* changes the whole method of drying, so that while the oil acid takes up oxygen rapidly, it does not become hard, but changes into a sticky oxy-linseed oil acid.



The practical inference is that whatever unlinks the oil acid from the glycerine ether is injurious to good drying, if it leaves the oil acid free. The natural impurities in the oil tend in this direction; so also do all acids used to clarify the oil.

This probably is what happens whenever a color becomes fatty. A hot paint mill is one cause of "fatty" colors, and heat separates the oil acid from the glycerine ether. Acids are another. Lakes are apt to run fatty; they may contain sulphuric acid

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* As in an oil kettle.

loosely combined with clay, and these *may* set the oil by the ears.

Well-kept oil becomes better with every month and even half-year, largely, apparently, because the oil acid becomes loosened from the glycerine ether.

Fresh oil dries slowly, but there appear to be decided differences in oils.*

As to fatty oil, its very slow drying fits it for painting roofs, where an oil is needed which will not dry up.

Oxy-linseed Oil Acid may be white or blood-red. It becomes red on heating it, and the sunlight makes it more or less colorless, because, apparently, it takes up water from the air, which becomes linked with the oil acid, and which is driven off again by the heat. One hundred parts of oil, made red by heating, were spread in the sun and became colorless, gaining in weight 6 parts:

	Parts.
Red oxy-linseed oil acid, by weight	100
Water	6
Colorless or white oxy-linseed oil acid	106

THE NOT-DRYING OIL ACIDS.

Linseed oil contains one-fifth of not-drying oil acids. What is the effect of these upon the oil can only be shown by their effects when in excess in the oil. These are given in some experiments by the French chemist Chevreul,† who was interested in the

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* It is not denied that the "foots" in oil injure its drying quality, and may be a cause of difference between old and new oils. It is simply not asserted, for reasons to be given in another article.

† The same who wrote about colors. He was one of the greatest of practical chemists.

question whether not-drying oil acids could be made useful in painting.

TABLE NO. 8.

Experiments with Oleic Acid and Linseed Oil.

	Mixture A.	Mixture B.
2 p. m. An oak door was given 1st coat, part A, part B.	Oleic acid...2 parts. Linseed oil...1 " Turpentine...1 " Drying oil...0 1-5 " Zinc white.	Pure linseed oil.4 parts. Drying oil......0 4-5 " Turpentine.....1 " Zinc white......
Jan. 9.	Perfectly dry.	Perfectly dry (2d coat).
" 11.	"	"

It was evident from this and other experiments that there was no difficulty in drying the paint. But Chevreul says: "The two paints present some differences to the eye; the paint with oleic acid being sensibly duller. But its capital defect is a lack of adherence to the wood; the friction of the nail is sufficient to remove it." In a number of other experiments with paints adulterated with oleic acid, there was the same difficulty—the paint remained soft. In only one instance (white lead was used with the oil) was the paint hard and adherent to the wood.

These experiments illustrate the influence of the not-drying oil acids, they keep the linseed oil softer. If we would have a hard oil we must harden them; if they entirely disappear the oil will become too hard.

The effect of an adulteration of linseed oil with fish oil is also illustrated; the oil would remain softer, would be more influenced by heat and cold, but would not "dry up." On tin roofs fish oil is valuable in keeping the linseed oil softer and more flexible, especially under the heat of the sun when the roof expands most. The acids of fish oil tend to rust iron.

The fatty oil acids of the linseed oil partly change into rancid acids and fly away. If the oil contain too much, it is probably more affected by cold; if it contain too little (as when the oil becomes very dry), the oil becomes more brittle. It seems reasonable that a mixture of a small part—one-tenth or one-eighth—of cotton-seed oil should be an advantage for galvanized iron and other smooth, hot surfaces. Softness of paint must not be confounded with the elasticity; nothing is less elastic than *cold*, solid fat, while *properly* dried linseed oil contains a true oil-rubber, which, so long as it lasts, gives the oil-leather some of the qualities of India rubber.

Some one should, however, try mixing suet fat (hot) with linseed oil for zinc or other hot places. It is doubtful what it would do (not more than 1-10 should be used) but it would probably keep the linseed oil soft, except in very cold weather.

CHAPTER X.

DRIERS OF DRYING OIL.

A LITTLE DICTIONARY. *Oxygen.*—One-fifth part of the air; the burning, rusting, change-producing element of the air. We breathe oxygen; get fire and light by causing it to unite with wood and coal; it rusts our iron (the iron in our blood), and we live by it; it rusts our iron bridges, and we die by them; we "dry" our oils and burn our oils by oxygen. There is no substance of whose effects we know more by *experience.*

Carbonic Acid.—The little and heavy gas of air. The product of decay, it produces decay in all living things which do not destroy it; not immediately, but by shutting out oxygen. Living plants change it into starch, starch becomes oil, oil changes again into carbonic acid and water. Carbonic acid destroys lifeless plants (trees and wood) rapidly. Iron rusts quickly in carbonic acid with oxygen. White lead is the rust of carbonic acid and lead. It is a fact of daily experience. *It is only the names of these things with which the painter is not familiar.*

Glycerine—To be had of your druggist. It is made from oils and fats.

Glycerine Ether.—Glycerine as it exists in oils, united with an oil acid.

Oil Acid.—An acid which when linked with glycerine ether is known as an oil.

Oil.—An oil acid linked with glycerine ether, and from which glycerine and soap can be made.

Soap.—An oil acid linked with soda, potash, lead, zinc, iron or some such substance. Some soaps do not dissolve in water.

Free Oil Acid.—An oil acid unlinked from glycerine ether, but not united with another substance.

Flying Oil Acid.—An oil acid which becomes lighter than air (due to action of heat or light) and flies away as would a gas.

Oil dries by taking up oxygen from the air, the result being an elastic varnish. With pure oil, however, this takes place only under the influence of light or heat. Light is the first and most important drier of oils, heat is only second to it; both are drying forces.

There are, however, many *substances* which act as driers, and some as anti-driers, as the following experiment will show:

The following substances were painted with linseed oil, linseed oil and white lead, and linseed oil and zinc white, the drying in each case being in the number of days indicated by the figures:

TABLE NO 9.

	Linseed oil..	Linseed oil, white lead.	Linseed oil, zinc white.
Copper	5	2	2
Brass	2	2	3
Zinc	3	3	4
Iron	3	3	3
Lead	1	2	1
Varnished porcelain	4	5	4
Not varnished porcelain	3	3	4
Glass	3	3	4
Plaster	4	3	4
Panel of poplar wood	9	5	10
" fir "	15	9	9
" oak "	159 for	3 coats.	—

This experiment was made by the French chemist Chevreul, a most skillful man. He was specially interested in the quick drying of oil over lead and the slowness of its drying on a panel of oak. He found it would dry somewhat faster upon the bright lead (scraped lead) than upon the dark surface or lead rust which usually coats the surface of this metal.

TABLE NO. 10.

	On scraped lead.	On dull lead.
First coat.		
May 19, at 1 o'clock	Linseed oil	Linseed oil.
" " " 3 "	Set	Fresh.
" " " 5 "	Nearly dry	Set.
" " " 6 "	Dry	Set.
" " " 8 "	Perfectly dry	Nearly dry.
" 20 " 9 " a. m		Dry, but tender.
Second coat.		
May 21, at 8 o'clock a. m	Fresh	Fresh.
" 22 " 8 " "	Beginning to dry.	Beginning to dry.
" 23 " 8 " "	Nearly dry	Nearly dry.
" 24 " 8 " "	Dry	Dry.

The first coat dried in a few hours, the second coat in five days. The difference was due to the lead with which the first coat of oil was in immediate contact.

Lead and Oxygen.—We cannot give with certainty the reason why oil on the lead dries faster. But we know what occurs when bright lead is exposed to moist air, especially if an acid is present. It quickly becomes linked with the air oxygen. The black film which was scraped from the lead was a thin coating of oxide of lead. The pure lead has a strong liking for oxygen, and will even take fire if very finely divided and thrown into the air.

When lead is heated it takes up oxygen from the air and becomes

		Parts.
Yellow Lead	Oxygen about	4 to 7
	Lead	93
		100

If this yellow lead is melted, it becomes litharge. If heated to 600°, it becomes red lead, which is a compound of yellow lead and another lead which contains twice as much oxygen.* These changes come by taking up oxygen from the air under the influence of heat, and therefore resemble the drying of oil.

The Oxygen of Driers.—Curious substances have been mixed with oil, as driers: bread, onions, garlic, etc. Mulder likens them to the mixtures in a witch's cauldron. It is evident why lead compounds, especially litharge and red lead, act as driers; when they are heated they give off oxygen and become to the oil like concentrated air. Other metals also unite with oxygen —iron, zinc and manganese. The following table shows the drying of warmed linseed oil, and a mixture warmed for two hours of oil and iron paint (oxide of

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* Red lead contains over 9 per cent. of oxygen.

iron), oil and litharge; oil and red lead, and oil and zinc (oxide) white.

There are two objects to be accomplished by these tables: 1, to show in the plainest figures the effect of the driers on oil; 2, to make the painter more familiar with what a long process "drying" is. The figures are easily understood, those marked with * being losses, the losses and gains being added together at the foot. After the net gain is given, the oil is warmed by 176°, and the loss stated is that caused by the flying away of the soft, non-drying acids, which have been changed into rancid acids by the oxygen of the air. Finally, a table of percentages of gain and loss is given. The oil was weighed each day.

TABLE NO. II.

	Warmed oil. Grams.	Iron oxide and oil. Grams.	Litharge and oil. Grams.	Red lead and oil. Grams.	Zinc white and oil. Grams.
April 28........	1.389	1.961	3.549	2.407	2.576
" 29	nothing.	nothing.	0.122	0.195	nothing.
" 30........	"	"	0.028	0.028	0.007*
May 2.........	.008	"	0.015	0.015	nothing.
" 3..........	.011	"	0.011	0.004	0.032
" 4..........	.012	"	0.007	0.002	0.050
" 10..........	.144	0.026	0.010	0.006	0.197
" 14..........	.010	0.166	0.012	nothing.	nothing.
" 21..........	.012*	0.012	0.012	0.010*	0.009
" 28..........	nothing.	0.006*	0.014*	0.014*	0.005*
June 4.........	"	0.005*	nothing.	0.002*	0.005
" 11.........	"	0.007*	0.008	nothing.	nothing.
" 18.........	"	0.004*	0.004	"	"
July 26.........	0.009*	0.010*	nothing.	"	"
Gain...........	0.185	0.204	0.329	0.250	0.293
Loss.	0.021*	0.032*	0.014*	0.026*	0.012*
Net gain.......	0.164	0.172	0.315	0.224	0.281
Heated, there was lost....	0.047	0.069	0.067	0.086	0.139
	0.117	0.103	0.248	0.138	0.142
		Percentage (by weight of oil).			
Net gain.......	11.9	11.4	12.5	13.2	12.6
Loss by heating.	3.5	4.6	2.6	5.0	6.2
	8.4	6.8	9.9	8.2	6.4
		Amount of oil in each paint.			
	Grams.	Grams.	Grams.	Grams.	Grams.
	1.389	1.511	2.512	1.695	2.235

The well-known slowness of drying of zinc white and of iron oxide paint are plainly shown by the table. Iron does not to any extent give up oxygen to the oil. The litharge and red lead paints, however, immediately give up a large amount of oxygen, and we observe that the litharge gained nearly 5 per cent. (of the weight of its oil) in oxygen, and the red lead over 11 per cent. on the first day.* The iron oxide paint and zinc oxide paint gained nothing for many days.

Black manganese and umber are both used in drying oil. They both contain the metal manganese linked with oxygen gas. Umber is composed of manganese and oxide of iron ; black manganese contains about 37 parts of oxygen.

Some experiments by Chevreul show very plainly the powerful drying properties of manganese and litharge, and also the singular fact that where a large quantity of drier is used and settled from the oil, it acts a second time with greater power when boiled with oil.

TABLE NO. 12.

1. Linseed oil boiled 5 hours	38 days in drying.
2. Linseed oil boiled 5 hours, with new peroxide of manganese	2 days in drying.
3. Linseed oil boiled 6 hours, with peroxide of manganese which had been used many times before	½ day in drying.

Another singular fact came out in Chevreul's experiments. He compared the power of an oil boiled with manganese with a mixture of this oil (so boiled) with 156 parts of pure oil. He found that the mixed oil—which, of course, contained much less

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* Possibly the chief cause of the gain was the effect of the lead on the oil acid.

drier*—absorbed much the most oxygen from the air, as will be seen by the following table :

TABLE NO. 13.

Volumes of Oxygen absorbed by Oils.

	Pure oil. No. 1.	Boiled oil. No. 2.*	Mixed oil. 156 parts of No. 1. 44 " No. 2.
Oxygen taken up in 3 days.	1.81	0.30	3.26
" " 9 "	1.77	3.00	8.95
" " 18 "	2.18	6.75	19.73
" " 30 "	2.54	21.45	30.82

This experiment was made by exposing the oil to oxygen gas, and it shows that driers not only give up to the oil such oxygen as they may have, but that they continue to take oxygen from the air, and give it up to the oil. Umber and manganese act in this way. The reason for heating them with the oil is that they both take up oxygen from the air and give it more rapidly to the oil when heated than when cold.

BOILING OIL (WITHOUT DRIERS).

C. W. Vincent (of London) has had a very large experience in boiling oil for printing inks, and has made many experiments with it. He states that a body of oil heated so that no air reaches it, except on the surface, as in heating in a common kettle—such oil heated for several days becomes thicker, more greasy, and has decidedly less drying power.

He also states that of many hundreds of samples of

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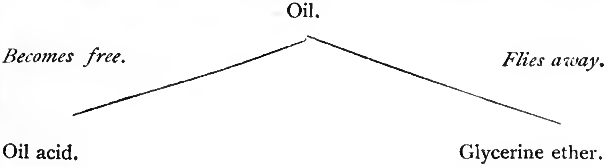
* The oil boiled with the manganese had already taken up much oxygen ; it would therefore be able to take up less. The experiment does not show that more oxygen is taken up when less manganese is used. Table No. 5 (Page 68), shows that oil (with slow-drying zinc-white) was in oxygen gas dry in 24 hours. It will be seen, therefore, that all the oxygen taken up after 24 hours was the over-drying of the oil ; and the possible effect of manganese driers in over-drying the oil is in some degree shown by the above figures.

oil taken at various stages of heating and boiling, not one dried more rapidly than a sample of raw oil from which it had been taken.

If oil is heated in the air it certainly, as we have seen, takes up oxygen more rapidly ; why then should it not dry more rapidly after heating for many hours, or even several days? These facts show the need of a close study of our subject.

Changes in Oil under Heat.—Oil is, as we have seen,



When oil is heated to 176° it begins to unlink, the glycerine separating from the oil acid and flying away. Some oil acid is thus left free* so that a heated oil is soon a mixture of oil and free oil acids.

As we have seen, these free oil acids, *i. e.*, acids unlinked from the glycerine, dry very slowly. They take up oxygen and increase in weight, but they remain as sticky oil acids for a long time. Free oil acids unite with lead or iron or maganese, and form soaps. Driers, therefore, not merely give up oxygen to the oil, but they harden it by changing the free oil acids into soaps.

These soaps, which are formed by the linking of oil acids with the driers, become very hard as they dry, but they also become *brittle.* Oils may be injured by driers if too much of these soaps exist in the dried oil.

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* Not merely free, but without much oxygen united with it or to unite with it.

Raw Linseed-oil Soaps.—Potash, soda and ammonia soaps of linseed-oil acid dissolve in water. Other soaps do not. Barytes (sulphate of baryta) does not form soap when mixed with the oil. Carbonate of baryta and lime soaps become quickly red in the air. Whiting gives little, if any, soap with linseed oil, at least not for a long time. See Putty.

Verdigris forms a soap which tends to become dark with time. Zinc forms soap very slowly, and its soaps do not quickly change in color.

The most important soaps are lead soaps, which will be further spoken of. Iron soap tends to yellow.

Mixed with raw oil more soap is formed by some substances than others.

Linseed oil contains glycerine ether	8 parts.*
Potash sets free of " "	6 "
Lead " " " " "	4 "

or only one-half. Lead apparently changes only one-half of the oil into soap.

All linseed-oil soaps dry more quickly—much more quickly—than the free oil acid unlinked from the glycerine ether. *One reason of this is because the free not-drying oil acids are hardened by becoming soaps. One-fifth of the oil consists of soft not-drying oil acids.*

Boiled Oil Soaps.—Lead, manganese and zinc and other substances give more soap in boiled linseed oil because it contains an abundance of free oil acids. These are hardened by the soaping and quickly dry into hard, brittle substances. Red lead gives the hardest soap.

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* These figures are not exact ; as far as possible decimal figures are disregarded in these articles.

To sum up the action of driers, they probably act in three ways:

(1.) By giving up oxygen to the oil, which also loosens the oil acid from the glycerine ether.

(2.) By forming soaps with all free oil acids, and hardening them. These are the soft not-drying acids, and the sticky oxy-linseed oil acid.

(3.) By continuing to take up oxygen from the air, feeding it to the oil. This is certainly true of manganese; but probably not to any extent of lead which is not heated. It is possible that manganese driers harden the oil more by feeding it oxygen; lead driers by making more of its acids into soap. If this is the case, it is an important fact in the wearing of the oil, which will be discusted by and by.

CHAPTER XI.

THE CAUSES OF DECAY IN PAINT AND VARNISH.

Having discussed already briefly the kinds of decay to which paint and varnish are subject, we may now enter more particularly into the causes of these:

Perishing.—This is not a serious evil, because it can be remedied. Sunlight—not the scattered light of a bright day, but the sun's direct rays—must be given a large place as cause. "There is a curious proof of the effect of the sun on varnish in the room where I am writing. A piece of carved oak furniture is so placed that one side of it is often in the full sunshine and the other generally in the shade. It was varnished about 20 years ago with an oleaginous solution of copal. This has now entirely disappeared, having been as effectually removed by the sun as it would have been by some powerful detergent, but the other side has retained its varnish well."—Hamerton.

Linseed oil, as we have seen, contains one-fifth of not-drying acids, which keep the oil softer. The sunlight causes the oxygen of the air to change these into rancid oil acids which fly away, leaving the oil harder and more brittle. As a matter of experience, a roof painted in October will last about as long as a roof painted six months later—*i. e.*, in the May following. The entire winter is saved in time. The same is true to a much *less* degree with house painting, and all painted work exposed to direct sunshine.

It must not be supposed that this is entirely due to the loss of not-drying oil acids. On the contrary, it is in large measure due to the over drying of the linseed-oil acids. They become dried up too much when exposed to a hot sun, losing all their elasticity. Nevertheless, on iron and tin, and especially zinc, the loss of the not-drying oil acids is a very serious matter—much more serious than upon wood.

Manganese driers, especially in the sun, are to be accused of a tendency to destroy paint and varnish, while lead (red lead) has somewhat of a preservative action. Manganese driers, there is strong reason to believe, take up oxygen from the air and give it up to the oil. If this be the case, the natural action of sunlight will be increased by manganese in the oil.

Finally, in the case of varnish, water, as has been shown, causes the gums to separate from the oil. Probably Kauri gum is much more quickly affected than the African copal.

The pigments, white lead, etc., will be treated ot by themselves ; but it may here be said that, except those which unite chemically with the oil, the question of the lasting of paint in regard to different substances used with the oil is a question how much these are affected—not in color, but in substance—by light, air and water. Zinc white, for instance, is (possibly) affected by the carbonic acid in rain water.

If a barrel of zinc white be left exposed to air it changes and loses much of its covering power. It can, however, be cured of this change by heat.

The fine particles of pigment mixed with the oil serve to hide the oil and protect it from the *air ;* and if these are stable, so is the paint.

Wearing Away.—Aside from perishing from chemical causes (light and air and water), there is a wearing process at work from rubs and injuries of all kinds, but especially from the friction of sand, hail and rain blown against the paint by the wind. On cars, especially, the paint and varnish must withstand the action of a true sand-blast composed of sand and cinders blown violently against it. Carriages suffer also from dust. The ends of cars suffer severely in this way; and for this reason need a *hard* paint. The "gums" with which varnish is made serve to harden it, and especially to protect it from the oxygen of the air. Oxygen uniting with the gums tends in some measure to harden them, so that parts under the surface are protected from the air. A hard paint is needed for nearly all exposed surfaces, including iron, where hardness is a great injury unless united (as it can be) with great elasticity. Hardness and elasticity are opposing elements in a paint, yet it is possible to have both One of the chief qualities of a lasting paint is hardness.

On carriages, the influence of the ammonia gas of stables must be taken into account. The running gear suffers from the ammonia, and the clay and other substances in the street, but specially from the organic matter (manure, etc.).

In this connection, on cars, may be mentioned an influence which has some effect also in cities. Coal contains sulphur, which, with water, produces sulphuric acid. Therefore bits of wet coal and smoke must have a considerable destructive influence.

I have seen no proof that in small quantities this influence on lead paints is injurious otherwise than by blackening them. It does not necessarily destroy the substance of the paint.

As soon as the general causes, of which we have been speaking, have fairly begun their work of destruction, the disease of cracking sets in and rapidly urges on the decay, because through it the air and water reach the interior of the paint and varnish and even the wood. One might easily grow eloquent upon the causes of cracking. In general, however, there are two causes—want of elasticity and too much and a too unequal contracting force.

The elasticity of oil may apparently be destroyed in three ways: (1) by making too much of its acids into hard soaps, which become brittle on drying; (2) by drying the oil too much by the use of driers remaining in it, or in other words, hastening the decay which takes place by the slow action of the air and sunlight; (3) by depriving it of its not-drying oil acids at the wrong time. If the dried paint is heated it loses from 3 to 5 per cent. in weight. It is much better that this loss on *inside coats* should take place before the varnish is thoroughly dry; and heat is to be recommended for varnish and paint, *both because it dries all coats while all are elastic, and because the loss of substance takes place while the oil is still elastic and soft enough to adjust itself to loss.*

But very much the most active cause of the cracking of paint and varnish is too much contracting force unequally distributed. In other words. the cracking of paint and varnish is due to unequal amounts of oil in adjoining coats, and unequal rates of drying.

A rubbing varnish over a finishing varnish is a good illustration of cracking due to unequal drying. An American varnish over an English varnish is a good illustration of unequal amounts of oil in adjoining coats. Too great thickness of a drying layer is still another illustration, as when a varnisher lays his brush upon a piano on which he is at work. Brush this spot over as he will, it will quite certainly crack.

Dr. Liebreich, of London, has studied the cracking of oil paintings, and finds that the cracking tends to follow lines running through those portions of the canvas on which the paint is thickest. It is important, therefore, that we get a proper conception of the causes at work, and a proper method of investigating these.

It is a more or less common practice to scratch away the paint or varnish from a cracked surface in order to discover the coat which has done the evil. I may be mistaken, but this appears to be a very misleading method. Except from over-drying on the surface of old varnish and from the action of cold, at least two coats are always engaged in any cracking, and these may crack coats above them, and under them, and once begun, the cracking may extend to the wood. Cracks of the same kind may and do extend to different depths, and while it may be possible by examining the direction and depth of a number of these to reach an opinion, the process is quite different from the ordinary method.

The causes of cracking are want of elasticity, the force and especially the inequality of the pull. Adjoining coats should be fairly dry, or else dry in equal times. This, however, they cannot do absolutely, because one is more exposed to the air than the others. But by the action of heat on the paint or varnish such a condition can be approximated. Under heat the outer coat is rendered elastic; the inner coats, apparently, take up oxygen from it ; and the glycerine ether and the two or three per cent. of non-drying acids fly away. The best conditions of drying are thin coats subjected to diffused light and heat.

It is an experiment worth trial, namely, a heated, well-glazed room or house, in which cars, carriages, furniture and such nice work could be subjected to much more light and a more uniform heat than is to be found in the ordinary shop. The glass of such a house, or of the windows of a shop, should be free of all imperfections or "bull's eyes." These concentrate heat and light like a lens, and produce most "unaccountable" blisters on the paint and varnish. It is possible that under too great heat the wood might contract and crack varnish, but this is not probable. Near me, as I write, lies a piece of white-wood, on which, as green wood, four or five coats of varnish were quickly placed, and the surface then subjected to a strong heat for days. No cracks appear. In this case but one side of the wood was covered, but all panels should be treated on all sides, because there is *much more danger of the wood causing cracks from expansion by absorption of moisture than from drying out* by heat or otherwise.

Peeling.—On wood, paint which is built on priming that has penetrated to the wood cells has many points on each inch of surface to which it is fastened. On iron it has very few points to the inch, and the value of red lead on iron seems to be its power of holding itself together over the iron—*i. e.*, its elasticity and firmness as a paint-layer. The secret of painting on iron is to use an oil which shall remain sticky as long as possible, or else a paint (red lead) which shall have the power of holding itself together

One occasional cause of peeling is a heavy coat of paint or varnish which has an uneven pull. Such a coat —or rather coats, for it comes only after many—cracks, and tends to curl* on itself, and, with the assistance of the water which comes to the wood through the cracks, tears itself from the wood. Cracking may, therefore, be said to end in peeling, for this is the general course of destruction.

WHY DO COATS CONTRACT?

It has been shown that oil gains about 10 per cent. in weight in drying! Why should it then contract, and so cause cracking?

Drying mud cracks open because it loses water; each little particle draws nearer to each other one, and the force of all opens a cleft at some point, because different masses of the mud particles pull together in different directions. Meanwhile little tubes form in the mud, these suck up water from the wet mud below, the water accumulates in little spaces, and causes, apparently the pores—air spaces—in the dried mud.

Dried oil and varnish, however, do not lose in weight, and have no pores.

Fresh oil is lighter than water. Dried oil is heavier than water. One is a fluid, the other a solid—that is, the particles of oil are not so close to one another as the particles of dried oil or varnish. Oil in drying contracts, because each little

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* The ends of layers of a heavy coat, peeling in this way, were examined under the microscope. The middle layers of the coat were in waves, owing, perhaps, to the heavy pulling of an old coat of English varnish.

particle (atom) pulls each other particle with more force than before. The oil has drawn itself together as it linked the oxygen gas to it. Oil contracts because it has gained something ; varnish contracts even more because it loses something, namely, its large volume of turpentine, which was placed in the varnish to keep it fluid.

Both oil and varnish continue to contract (the particles to move toward one another) so long as oxygen continues to unite with the oil. This, as we have seen, is for many months—usually for at least 150 days. The elasticity of the oil depends upon the fact that it is not all dry All the *undried* linolein (linseed-oil acid) gives the oil elasticity, but whatever remains when another coat is placed over it will be dangerous to that coat, because it will continue its drying and contraction. Again, the oxygen, as it continues to unite with the not-drying oil acids (one-fifth part of the oil), changes them into flying oil acids, which are either gradually or suddenly (by some hot day) flying away and leaving less oil, and that of a firmer and harder nature. These changes continuing upon the surface gradually make the outer coat so much less than the under coat that it begins to part, and gives those fine, pale lines which may be seen on the surface of old varnishes with a good magnifying glass, running always across the grain, because all motion, as we have shown (contraction is motion) is easier in this direction, and because the shrinking of wood under the varnish in the other direction makes that pull much less.

For the above reasons the best preservative of well-dried varnish is oil--a *little* oil rubbed thoroughly over its surface. This will protect from air (oxygen) and from heat and cold. Only experienced hands are fit to do such work on fine jobs—it should be done from time to time—because too much oil gums and injures the appearance of the varnish, making it a complete dust-trap. On rough work, however, it will serve equally well as a protection, and is the only thing which will prevent varnish over hot engine boilers from going to pieces. Such varnish quickly goes to pieces from the contraction of cold. Cold air does not affect it so much as cold rain, nor this nearly so much as snow, which cracks it like so much brittle glass if it be not oiled.

Sun-cracked varnish breaks across the grain, water-cracked varnish breaks with the grain.

I have not spoken of the action of cold in destroying and cracking paint and varnish, because, although certain, it is not a force which has been measured, and cannot be prevented except by using pure linseed oil. (See table under Drying Oils.) In very cold sections, pure linseed oil alone should be used ; but the experience with fish oil on roofs, and the facts of the drying of oil indicate that, for iron and rough woodwork, a little half-drying oil (never more than ⅛) *may* be an advantage to linseed oil. It should not be forgotten that this will increase the danger of cracking in the next coat.

We present the following bits of testimony in confirmation of the views of this article.

THE CRACKING OF PAINTINGS.

Light from all sources on the question will lead to greater certainty, and therefore the researches of Dr. Liebreich on the cracking of oil paintings have a certain value.

It is very important that artists should have exact knowledge of these matters. But it seems to me that they are insufficiently known to most of them. Otherwise the custom of painting with the ordinary oil colors, to be bought at any colorman's, would not have been going on for nearly a hundred years in spite of all the clearly shown evil results; results due, chiefly, to the principal economy of oil painting, that is to say, the use of oil. (Dr. L. here speaks of oil as oil, not of its adulterations). That the masters of the fifteenth and sixteenth centuries did not use colors prepared in this way, you may consider absolutely certain; and if we hear the lost secret spoken of, and if we read that the pupils of the old masters had to pledge themselves to keep the secret, we may be sure that it is neither the method of painting nor the pigments used, but exclusively the way of preparing colors. The preparation was a very complicated one, varying with the different pigments, and we know that the pupils passed six years, that is, half of the apprenticeship, in grinding colors for the master.

If we compare the pictures of the Italian and Dutch schools of the 16th, 17th and 18th centuries, with those of the French and English schools of the last hundred years, we are struck by the great difference in the nature of their diseases. We may divide those diseases into constitutional ones—that is to say, those based on the methods and materials used in painting and those produced by external influences. The Dutch pictures of the 15th, 16th and 17th centuries, and the Italian pictures of the 15th and 16th centuries seem to be perfectly free from constitutional diseases.

It is only in the 17th century paintings show a special constitutional alteration caused by the practice of the Bologna school.

The constitutional quality of their time and school was the too great contrast between light and shade, too weak half tones, and glazings spread on dark ground, which had been destroyed by the growing bolus and umber of the painting.

The constitutional diseases of pictures belonging to the French and English school of the last hundred years are of a still more serious nature, and much more difficult to cure. Many of these, though never exposed to any injury whatever, cannot be guarded from premature decay, in spite of all possible care with which they are kept.

The principal symptoms of their bad constitutions are:

(1) Darkening of the opaque-bright colors.
(2) Fading of the transparent brilliant colors.
(3) Darkening, and above all cracking, of the transparent dark colors.

The best opportunity to study these several appearances is given us in the Museum of the Louvre, which contains a great number of such pictures in the section occupied by the French school.

I have paid much attention to the cracks in these pictures, as I find that in shape, in size, in position, as well as in relation to the various colors, they differ distinctly from the cracks in the older pictures and in those of other schools. The special characteristics of these cracks are the following ;

They are all but exclusively found in the thickly laid on transparent dark colors, and they are the deeper and more gaping in proportion to the thickness of the layer of the color, and the extent of the dark surface. The chief cracks run parallel to the outlines of surfaces painted with bright opaque colors, such, for instance, as are used for flesh tints, and which are more or less thickly laid on.

But there is generally a slight distance between the bright colors and the cracks.

Lateral branches of these cracks pass into white surfaces but they do not gape, provided the white colors had been laid on directly upon the priming and not upon a layer of dark transparent, but not sufficiently dry color.

This examination of the cracks of pictures has sometimes afforded me a peculiar insight into the practice used for the picture. In the well-known picture by Guerticault of "The Wreck of the Medusa," in the Gallery of the Louvre, the cracks follow exactly the outlines of the bright flesh tints. The arm of one of the dead bodies hanging in the water is so covered by planks and water that nothing of the forearm is seen. It is, however, very easy to prove that originally this arm was painted in its length, for the cracks do not only follow the outlines of the arm as now seen, but also the outline of the no longer visible forearm and all the five fingers. This proves that the fore part of the arm and the hand were originally painted in flesh tints before they were covered over by the paint of the planks, and the water painted afterward.

In Ingres' portrait of Cherubini, the face of the latter is beautifully preserved, while that of the Muse, as well as her drapery, is covered with cracks. In the depth of the cracks of the white drapery an intense blue tint is seen. Ingres painted the head of Cherubini in Paris, and then took it to Rome. There it was pieced into new canvas and lined. Then the Muse was painted, and before the colors were perfectly dry, another model was chosen, and a new Muse painted over the old one.

The color of the drapery was likewise altered, and this explains the cracks in the white color, and explains also why the blue appears in the depth of the cracks of the drapery.

Among English artists of the last hundred years, some have painted with the same materials, and by the same process as the French, and with the same unfortunate results. Others avoided these by using the same materials with more precautions.

The study of alterations already fully developed in the pictures painted within the last hundred years only, and their comparison with the works of the old masters, would suggest the following rules for the process of painting :

1st. The oil should in all colors be reduced to a minimum, and under no form should more of it be introduced into a picture than absolutely necessary.

2d. All transparent colors, which dry very slowly, should be ground, not with oil at all, but with a resinous vehicle.

3d. No color should be put on any part of a picture which is not yet perfectly dry; and above all never a quick drying color upon a slowly drying one which is not yet perfectly dry.

4th. White and other quick drying opaque colors may be put on thickly. On the contrary, transparent and slowly drying colors should always be put on in thin layers.

If the effect of a thick layer of these latter is required, it must be produced by laying one thin layer over another, taking care to have one completely dry before the next is laid on. If transparent colors are mixed with sufficient amount of white lead, they may be treated like opaque ones.

The varnish may crack or become dim; it should then be treated by Pettenkofer's method;* but it may become dark yellow, brown and dirty, and so hide the picture as to require its removal, when it should be replaced by a thin layer of fresh varnish.

If a picture is throughout painted in oil, if its substance has remained sound and even, and it was varnished with an easily soluble mastic or dammar varnish, then there will be neither difficulty nor danger in removing the varnish. The difficulty and danger are much greater in cleaning those pictures which have not been varnished with the ordinary easily dissolved mastic or dammar varnish, but have been painted over with oil, oil varnish (or oleo-resinous varnish). It seems incredible that these substances should ever be used for such purposes. It is, however, a fact that there are still people who fancy it will contribute to the preservation of their pictures to brush, from time to time, a little of those liquids over their surface. They recognize too late that the varnish becomes more and more dark, of a brownish color and opaque. If such varnish has afterwards to be removed, then we meet with the great difficulty, that this can be done only with substances which would just as easily dissolve the whole picture as the hardened layers spread over it.—*Synopsis of an article by Dr. Liebreich.*

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* See Appendix.

CHAPTER XII.

MANUFACTURE AND USE OF WHITE LEAD.

White lead, however made, is the rust of lead by carbonic acid gas, which may result naturally, but can be very much hastened by *artificial* heat and the artificial production of a large amount of the gas.

White lead also contains an oxide of lead combined with water.

The Lead.—Silver in the lead produces a white lead of pinkish cast ; bismuth in lead gives a whiter lead, but may also darken it by collecting in quantity in some portions of the lead during the melting. The melted lead is, for the *Dutch* method, cast into the form of large buckles ; for other methods the lead may be used in the form of sheets or of powder. In this country, with the exception of three or four factories, none of which are large, lead is made by the *Dutch* method or process. Other methods are the *French*, *German*, and modified forms of these.

The Dutch method, so called because it was first used in Holland of all European countries :

The buckles of lead are placed over pots, which contain vinegar acid (acetic acid of from .05 to .75 per cent. strength) the pots are placed in "stacks" (or brick chambers) on a bed of hard, fermenting tan. The pots are quite close together over the whole bed except for a space of about 8 inches around the walls. This space is filled in with tan-bark, a board separating it from the pots. The first bed is then floored over, and a second bed made in the same fashion on this floor. Ten or twelve beds are thus sometimes stacked and the top covered with a layer of tan bark. Some corroders of white lead use manure only; others a mixture of tan and manure, both serving the same purpose, namely, to heat the acid in the pots.

The manure, however, has the disadvantage of giving off sulphur-ammonia gas, which combines with the lead and produces black sulphide of lead. This is specially the case when the manure of pigstyes, and of flesh-eating animals, is used. The temperature of the pots reaches 140° to 200°.

The quantity of lead in a stack of 20 × 12 feet is three tons, which lies upon 1,000 pots (each 5½ inches diameter) containing 200 gallons of vinegar acid. The vinegar acid is gradually changed by the air which, in small quantities, enters the stack, into carbonic acid gas. At the time of stacking, the air will contain 20 parts in 100 of oxygen; after a fortnight only 17 parts, and in five or six weeks 15, 13 or even but 7 parts of oxygen, the carbonic acid in the air having increased from 5-10 of 1 per cent. up to perhaps 27 per cent.

A change in the lead before it is acted upon by the carbonic acid is required; and this is, apparently, the reason why the process cannot be safely hastened by at once increasing the amount of carbonic acid in the air.

The result of this impure air acting upon the lead buckles is white lead. Not all the lead, however, is changed to white lead, from 30 to 50 parts of unchanged lead remain, and must be separated. Of the white lead, 125 to 129 parts by weight represent 100 parts of lead. When the stacks have been up from eight to nine weeks they are unloaded.

The unloading, but more especially the separation of the white lead on the buckles from the remaining unchanged lead, is one of the most dangerous operations in white lead making. In some countries this is done under water by means of rakes; in others the dry powder is rolled and beaten on a stone slab with a sort of mallet, in which case the workman should have his mouth covered by a damp cloth or sponge to keep out the fine, dry white lead.

After this separation process, the white lead is ground in mills, commonly with water, and either dried or in its wet state re-ground with oil. In this country some of the most careful manufacturers use oil from East Indian flaxseed.

In other countries white lead is often sold in loaves made by binding the lead flour with gum arabic, acetic acid, lead, etc. In this country it is usually sold in kegs, ground in oil, which is in every way an advantage to both the durability of the painter and the paint. It probably lengthens the life of the whole trade; for grinding paint is one of the most common causes of lead diseases, especially colic, as shown by hospital reports and experience.

The German, Austrian, or chamber process of white lead manufacture is an improvement upon the Dutch or pot method. The lead is used in sheets about 1 inch thick, 8 inches broad and 12 inches long; 1,800 to 2,000 such sheets per box; 8 boxes in each chamber, containing from 22,000 to 53,000 pounds of lead. The walls of the chambers are lined with tin, and the chambers heated sometimes with steam. The carbonic acid which rusts the lead into white lead is made by the fermentation of vinegar, yeast and other substances, ammonia and phosphate of magnesia being added to hasten the fermentation. Carbonic acid from burning charcoal is sometimes introduced into such chambers. The *Kremser* white or *Klangenfurt* method is a German process, in which vinegar from dried grapes is used.

The best of these leads are said to be whiter than Dutch process lead, and to cover equally as well. Flake white is a pure white lead in scales. Krems' or Crems' white is a poor sort of Kremser white.

The Clinchy or French process is entirely different from the others. The white lead is made by passing carbonic acid (made from coke and chalk) through a solution of sugar of lead (*i. e.*, some kind of acetic acid lead). The passage of the gas through the liquid lasts from 12 to 14 hours. The resulting white or carbonic acid lead (which settles to the bottom) is more or less crystalline, loose and coarse in grain. It allows more light to pass *through* it, takes up more oil, and does not, therefore, cover nearly so well as Dutch white lead.

There are many different processes which may be classed under one of the above methods. H. Gruneberg's, in Germany, and Milner's, in England, are worthy of mention as producing (it is said) white lead equal or superior (in whiteness) to Dutch process lead, without defects and with advantage of safety for the workmen. Milner's process is used by the Sankey White Lead Company, near Warrington, England. The lead may be made in two days, by the action of carbonic acid on a lead (oxy chloride) made by grinding together litharge, water and common salt.

Gruneberg's process requires eight days, and results from the action of carbonic acid on very finely powdered lead and litharge, rolled constantly in cylinders. *Pattison's* white lead is an oxy chloride of lead, made by the action of muriatic acid on lead ore (galena).

A practical question, as we shall see, is whether the difficulty with much white lead is not in pushing the process through in a short time. If, as seems probable, white lead is more apt to powder than formerly, we are inclined to believe that here lies the fault. There may also be failure to *wash* the lead properly. The fresh lead contains loose carbonic acid and more or less acetic acid *mixed* through it; these acids must be washed out. It is probably the carbonic acid which causes *all* white lead to powder.

THE NEEDS OF A PAINT.

A paint needs hardness in order to withstand the friction (1) of rain and storm, (2) of fine particles of sand or cinders blown against it by the wind, (3) and injuries and accidents of all kinds which tend to rub off and deface its coats. The oil itself is also better for protection from the oxygen of the air, which, having hardened it, tends to harden it too much, and finally to change it into carbonic acid and water.* An oil varnish may be called a hard paint. It is made so by removing the soft, non-drying oil acids by boiling the oil, and also by changing them into soaps. Finally,

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* As an illustration of the protection of mere hardness a freshly painted and varnished car will often suffer severe injury by immediate exposure to a hot summer's sun. Its paint soon thereafter perishes.

the oil is hardened by mixing it with "gums." An oil varnish may be called a "gum" paint, and the hardening of oil is always produced in the same manner, namely, by mixing it with fine particles of hard substances. It remains to study the effect upon the oil of each kind of these substances—lead, zinc, iron, etc.

There are those who are inclined to believe that all soap-making between pigments and oil is injurious to the durability of paint. There is ground for this in the fact that white lead, which forms some soap with oil, is less durable then iron paints, which are, to a greater extent, merely powders held in a coat of dried oil. It remains to discover whether longer life is given to oil by changing it into a soap. It is, however, an advantage to get a hard paint immediately, if by so doing we can also retain the elasticity of the oil. This we accomplish by using red lead as a pigment. The red lead gives up some of its oxygen to the oil and changes part of it into an oxy-linseed-oil acid, with which the lead unites to form a hard oxy-linseed-oil acid, oxide-of-lead soap. And yet red lead is a lasting paint, long retaining its elasticity and a certain power of holding itself together, more lasting than iron paints (see Painting Iron).

We do not get this soap in the case of other substances united with the oil, because neither the zinc, iron, and only part of white lead, gives up its oxygen to the oil, although they all contain oxygen, while the red lead also gives a hard substance with which to unite with the oil acid—*i. e.*, it makes hard oxy-linseed-oil-acid, oxide-of-lead soap.

Of these facts we may be sure, if we can trust so able a chemist as Mulder.

Mulder's Experiments.—Having clearly seen the excellence of a red-lead paint, Mulder conceived the idea of making a good, cheap paint by combining (mixing) hard powders of cheap substances with it. For the oil, he took a boiled linseed oil, containing 2½ per cent. of lead oxide; 100 parts of this oil to each mixture. The iron paint spoken of consisted of substances as follows :*

Water	2.75 parts	71.02 parts.
Red oxide of iron	68.27 "	
Clay	27.60 "	28.27 parts clay.
Marl	.27 "	
Chalk	.40 "	

This was a purchased paint from a maker of iron paints, Cartiers, of Belgium. The other substances used were as finely powdered as possible. Two hundred parts of fine sand with 5 parts of red lead and oil gave a paint of some worth. Red lead 25 parts with 40 parts of iron paint gave a very good covering; 20, 40, 65 and 90 parts to 100 parts of iron paint were excellent. Twenty to 90 parts of red lead and 50 parts of red roof tiles gave a thick, heavy covering; 40 parts of red lead and 100 parts of roof tiles gave an excellent covering. Finally, 20 to 90 parts of red lead to 100 parts of powdered ironstone gave a paint of distinguished excellence. The iron plate on which these substances were painted was partly washed with sulphuric acid before painting. After painting it was exposed to wind and rain until the unpainted side was covered with rust, but no trace of rust appeared on the painted side. After 10 months Mulder speaks of the undoubted success of the experiment. The paints were holding well and evenly as very hard, thick

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* In the absence of American analyses of iron paints, the above is given in full as an illustration of their composition.

coverings. Mulder thus sums up the method of making a cheap, hard and well-protecting paint :

1. By boiling oil with 2 to 3 per cent. of oxide of lead (litharge or red lead) to harden the soft non-drying and free oil acids.

2. Some oxide of lead as pigment : red lead the best (uniting with and giving additional hardness to the oil).

3. Hard indifferent powders, made as fine as possible, and as much used as the mixture will bear as a good paint.

The Theory of a Good Paint.—The above seems to represent the true theory of a good paint.

We must have for a good paint substance one which not merely mixes with, but more or less links with, the oil. Barytes does not unite with the oil ; zinc does so slowly ; iron paints only partially, if at all—red lead is the substance which best fulfills this office, and it is the most lasting paint. White lead, as we shall see, owes all its value as a paint (not a color) to a substance like red lead, which it contains.

Nevertheless, red lead is the most dangerous paint for the painter.

Moreover, it is a difficult paint to obtain pure, and is more inclined to blister than are iron paints, which are also much cheaper. *We do not advocate the use of red lead*, but it is necessary to show the facts as far as they exist. The secret of a paint is to have some substance mixed with it, which forms a soap and *hardens the oil.* The valuable discovery would be a substance to replace lead ; until this is discovered, we advocate iron and zinc paints as far as they can be used, *mixed with lead.*

It is doubtful whether we can add lasting elasticity to a raw oil by boiling it, but we can possibly keep its elasticity longer and also harden the oil; and get a quicker drying oil.

Too much drier must not be used or the result will be too hard and brittle an oil, without elasticity.

WHAT IS WHITE LEAD?

The soap-making of white lead with oil is certain, but not easy to understand. The following appear to be facts, based upon the experiments of Mulder and on those of two English chemists:

White lead is composed of two kinds of lead. The whiteness and covering power are due to one, the strength and hardness of the paint to the other.

White lead consists of carbonic acid lead and water lead.

No. 1, in table 14 below, is a good, dense lead, specific gravity 6.32; No. 2, a dry white lead, specific gravity 6.50; No. 3 is a crystalline, transparent lead.

TABLE NO. 14.

	No. 1.	No. 2.	No. 3.
Oxide of lead	85.95	86.18	83.53
Carbonic acid	11.14	10.44	15 70
Water	2.91	3.37	0.75

TABLE NO. 15.

	Lead.	Carbonic acid.	Water.
White lead, best quality	86.80	11.16	2.00
" " 2d quality	86.24	11.68	1.81
" " 3d quality	86.03	12.28	1.68
Residue lead	84.69	14.10	0.93
Useless lead	83.47	16.15	0.25

White lead should contain:

Oxide of lead linked with water, at least	25	parts.
Carbonic acid lead	75	"
	100	

The carbonic acid lead gives the whiteness; the water-oxide of lead only hardness, but without it there is no paint, only a wash.

The difficulty with a very hard *white* lead which contains no water lead is that it will not harden, but easily brushes off like a lime whitewash. If abundance of oil has been used and this difficulty occurs, the painter may be quite sure that the lead has not been properly made. Carbonic acid lead produces some change in the oil; it makes it into a sort of emulsion. To make the matter very clear, we will suppose that this emulsion, like other emulsions, consists of very fine drops of oil which dry as drops and not into a continuous sheet as does ordinary oil. This may not be the explanation, however. If the reader will turn to Table No. 5 (page 68) he will discover that carbonic acid has some effect on oil. White lead paint in an atmosphere of carbonic acid was "set" in 24 hours, but was not adherent to the wood in 72 hours.

It may be that carbonic acid of carbonic acid lead unites in some way with oil. In any case, it is the carbonic acid lead which makes the paint white and which causes it to powder; it is the water lead which makes part of the oil into a soap and hardens the paint. Both, probably, add somewhat to the ease of working, so that we may illustrate the effect of white lead on oil by the effect of soap in washing one's hands. (See "Oils.")

The effect of soap-making, both in boiling oil with or without driers, and also in making a hard paint is, as we shall see, injurious to the *color* of the paint. Mulder recommended to artists a white lead which should contain no water lead, and therefore would produce no soap; but Messrs. Wigner & Harland, of England, have shown, as above, that this would not do as a paint. Mulder's conclusions harmonized with those of these English chemists, but were not so clear as theirs, for he was puzzled to find the effects of soap-making (ease of working of the paint) without other results produced by a soap.

The Powdering of White Lead.—As we have seen, at least one-fourth of a properly made white lead is a substance (water lead) which may be compared to red lead in its effect upon the oil. The other three-fourths of the lead injure the oil as a paint, but give all the covering power, as water lead (hydrated oxide of lead) has no coloring properties whatever. The powdering of the lead is due to this three-fourths of carbonic acid lead; the change in color to the soap-making between the water lead and the oil, producing more or less oxy-oil acid which in the shade becomes red. See Part II.

We venture to make these bold statements on these disputed points because the experiments of Messrs. Wigner & Harland, of England, combined with Mulder's work and observation, throw great light on the subject.

There may be another cause for the powdering of lead, as facts in our own experience indicate, and as Messrs. Harrison & Bros., of Philadelphia, state in their circular, namely, the use of too little oil with the lead.

Mulder speaks of 250 to 280 per cent. of white lead as recommended by practical men; but advises 52 parts as sufficient for all soap-making purposes for 100 parts by weight of oil. He admits, however, that very much more than this does not produce a hard, brittle paint, as it would do if there were much soap-making with the oil. Within the house 700 or even 1,000 parts by weight of lead to 100 parts of oil are used without producing a paint which is either brittle or powdery, and which has the great advantage of holding its color. We may, therefore, reasonably lay the blame of much, if not all, the powdering of white lead upon the carbonic acid, since Messrs. Wigner & Harland's experiments prove that a pure carbonic lead paint will entirely powder like whitewash. The hardening and quick drying of the lead is to be entirely credited to the water lead; but if we desire a lead which will undergo the least change of color, we must seek one with *at least* as little as 25 per cent. of water lead. Less than this will give us a bad paint.

The adulteration of white lead may be an advantage. Messrs. Wigner & Harland say that 5 per cent. of adulteration does not injure the covering power of the lead; but 10 per cent. does. Aside from loss of so great covering power, an adulteration of 15 per cent. would not be a great injury to paint for rougher outside work, and if done honestly, no injury to the man who should boldly state this to be his formula of composition.

White lead, as we have seen, is made by the use of acetic (vinegar) acid, and there remains more or less acetic acid lead in the product. If this is not thoroughly washed away, the spread paint has the appearance of "small pox," from dry, hard masses, produced by the acetic acid lead. These will form before the lead is used.

Lead made by the Dutch process is often not so white as other lead, because the manure which is used to produce heat about the pots gives rise to sulphur gas, which may unite with lead and form more or less black sulphide of lead. Tan is mixed with the manure, and in other countries tan and pyroligneous acid are used. The German process of making lead is in closets or chambers, not in pots; the French process, by passing carbonic acid through a solution of acetic acid (vinegar) lead. This gives a very white lead, but one containing large particles which are more or less in the condition of crystals. Stein says the French process lead soaks up more oil, and gives this as the reason why the lead does not cover so well. The truer reason is that given on page 35.

The red tinge in some white leads is apparently due to the presence of silver in the lead ore, which prevents some particles of lead from changing so rapidly into white lead as the other portions of the corroding metal. "In 1868 a large quantity of lead was decopperized by means of zinc at the Sheffield Lead Works, leaving a quantity of silver, which varied from 15 dwts. to 1 oz. of silver per ton. About 80 tons of this lead were placed in the stocks for corrosion when the whole of it came down of a uniform pink tint." Some of our soft American leads contain a little bismuth, which, being lighter than lead, sometimes collects at the top of the melting kettle, and buckles are produced containing much bismuth, which remain black in the carbonic-acid atmosphere where the white lead is corroded. Lead long mixed with oil (old tub lead) is much better than fresh lead; it covers better, and has been said to change less in color, but of this fact I am not at all sure. The change is not so much in the lead as in the oil. The carbonic acid lead produces an emulsion with the oil, that is to say, it separates it in some way, possibly into very fine drops. The long standing may allow the oil time to recover partly from this effect, and it certainly causes it to unite more closely with the water lead as soap. Old lead, therefore, for both these reasons, is stiffer and does not always work so easily, but can cover more surface with a harder and more permanent covering.

Practical Use of the Above Facts.—It is very generally believed, and on good grounds, that white lead bearing the name of even reliable firms is more inclined to powder than was the case years ago. Complaints arise on every hand, and the quality of lead purchased *should be*, and *we* are inclined to believe is, an assurance that the cause is not adulteration. Lead largely adulterated with barytes might powder in this way if the adulteration were considerable enough, but we doubt that any firm in good standing sells such white lead *branded with its firm or mill name.* Adulterated lead is undoubtedly found under second-class brands, or under a trade title as this or that "*White.*"

All white lead will powder, because, as we have shown, it contains carbonic acid lead. Lead not properly washed will dry in lumps or grains, because it contains acetic acid lead (which is a drier) and may also contain pure lead particles.

Finally, white lead, as found in the stacks after corrosion, differs very much in composition. Corrosions from the centre of the stack may differ very much from those at the side walls, where more moisture has been present. In some cases, with an excess of moisture, "corrosions are quite sugary in appearance, rubbing between the fingers into small crystalline grains, which, upon analysis, will be found to be *nearly pure plumbic* carbonate, $PbCO_3$" (carbonic acid lead).

It is not improbable that the cause of poor quality is due to improper or too rapid corrosion. Reference to the table of analyses on page 116 of this chapter will show (the analyses were made by a German chemist, Weise) a less amount of water in second and third rate lead than in lead of first quality, and the inference is that these contained less water lead.

But the question cannot be decided by any chemical analyses thus far made, because these do not agree with each other sufficiently All that can be said in view of the clear light from Mulder's, but especially from Wigner & Harland's experiments, and from confirmation by all the facts, is that the excessive powdering of any lead, not badly adulterated, is due to the small quantity of water lead it contains. What this is due to we do not positively know, except that it requires a certain time to make good lead by the Dutch process, usually from six to eight weeks. By other processes, good lead is made in shorter time; but none of these, we believe, is successful in this country

The whiteness of lead is due largely to the purity of the metallic lead used—it may also be due, as we have indicated, to the method of manufacture. The method of manufacture has much to do with the covering (coloring) power. All lead which contains crystals has less covering power, and this lead, made at least by some short modification of the Dutch process, is the one easily deficient in water lead.

All the mysteries of this subject cannot be cleared up, but I have given the reader those conclusions which seem to me best to harmonize with and to be supported by the best authorities who have made thorough investigation of this subject.

Although the matter has been discussed on the ground of scientific facts, the result must be *practical* and *not scientific* certainty—that is to say, it is the best light we have to-day *to act upon.*

CHAPTER XIII.

RUST.

The preservation of iron is a matter of such importance that the painter needs a good deal of knowledge about the causes of destruction which he, more than any one else, is called upon to prevent.

Gold and platinum have no rust. Silver is not at all affected by the oxygen of the air, but is blackened by the sulphur gases (sulphuretted hydrogen). The sulphur in eggs rusts silver, forming the black sulphide of silver so difficult to remove from a silver spoon which has been much used in eating eggs. Copper is little affected by the oxygen of the air, but forms a green rust (carbonic acid copper, or, with acids, verdigris, acetic acid copper, and the like). The rust of copper prevents further rust ; it forms, so to speak, a protective coat of color, usually green or bluish green. Copper rust is very poisonous.

Lead.—Lead attracts and unites with the oxygen of the air, and forms a thin black rust. This does not, however, increase unless the lead be heated or exposed to hot sunlight, when yellow and even red lead may be formed.

The true lead rust is white lead, and due to the action of carbonic acid in water or in the air. Soft rain-waters have much more effect than hard waters, and water containing sewage matter and fatty acids, cider and sour milk still more. Lead rust is poisonous.

Tin is very little affected by oxygen of the air. It loses its lustre (as tin plate), but the acid gases of the air—especially the sulphur gases—have less effect upon it than upon silver. Red lead softens tin, but does not rust it, although some tin may be changed into a white oxide of tin.

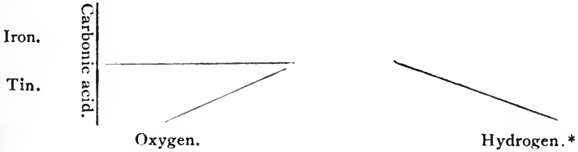
Tin plate is made by coating plate-iron (charcoal plate or coke plate) with molten tin. The protection to the iron is perfect, while the coating remains entire. When broken at any point, the iron rusts more rapidly for the presence of the tin.

Water is composed of two gases linked :

$$\overbrace{\text{Hydrogen.} \qquad\qquad\qquad\qquad \text{Oxygen.}}^{\text{Water.}}$$

Water may be broken up into these gases by a galvanic battery. Tin and iron, or zinc and iron, form such a battery, if an acid such as carbonic acid be present.

Tin and iron and the carbonic acid in rain-water act as a battery and unlink the gases of the water.



The oxygen of the water unites with the iron and, of course, rusts it more rapidly than the oxygen of the air would have done.

Zinc and iron act in the same way to water, but the unlinked oxygen attacks the zinc and not the iron.

The coating of rust which soon appears on bright tin plate exposed on roofs comes from the iron under-

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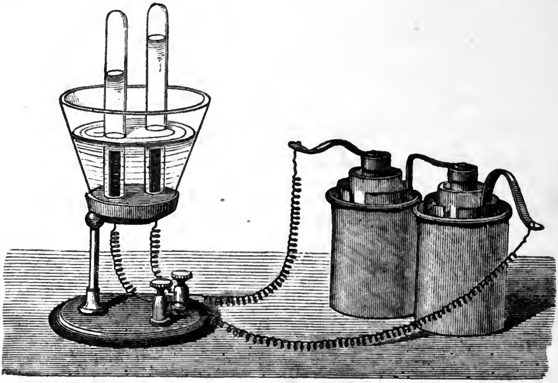
* The hydrogen may join with the nitrogen of the air to form ammonia, formed with iron rust.

neath through minute holes in the tin. If the tin plate be examined by a glass, holding the tin so as to reflect the light, a number of minute dents or holes will be discovered in its surface through which the water reaches the iron and the rust runs out. These are more numerous on the lighter tin, and on the heavier tin fewer are probably open to the iron. They are the holes by which the paint must hold to the tin, but in case of new tin they are already filled with grease, which must come out before the linseed oil can go in.



Production of odorous oxygen (the oxygen of the air has no odor) from water containing a little acid, by means of a battery. This form of oxygen is very powerful, and is called ozone ("to smell"). It is its odor which is perceived by the nose during the working of an ordinary electrical machine.

This is the reason why a roof is better for exposure for some days before painting; the grease must either be evaporated, or it must be run out by the rain-water and the rust. The oil can then get a direct hold upon the metal inside the holes.

This grease comes either from the top of the bath of tin into which the iron plate is dipped to "tin" it and which is placed there to prevent the air from acting on the molten metal, or it may be rubbed in during the polishing.

Zinc and Galvanized Iron.—Zinc is slowly rusted by the oxygen of the air—more quickly by moist air, and becomes coated with a white oxide of zinc, which protects from further rusting.

Galvanized iron has the same disadvantage as tinned iron: it acts as a battery to unlink the oxygen of rain-water. The oxygen, however, attacks the zinc, while on tinned iron it attacks and rusts the iron. It is better that the plates of corrugated iron should be galvanized after they are bent into waves, because this bending into shape is apt to crack the zinc. At least it is an advantage to get plates which have been regalvanized after bending, to fill up cracks.

Zinc of galvanized iron is quickly acted upon by sea air, and by all acid air. Soot is very destructive to it, soot, zinc and the carbonic acid of rain-water forming a battery like those described above.

Soot is a compound of ammonia; the urine and dung of animals contain acid and become ammonia. Therefore all these are destructive to zinc roofs, and cats especially should avoid such hunting-grounds. Lime-water and water from oak wood are also injurious to zinc.

The Chemistry of Iron Rust.—The rust of iron is always a linking together of the oxygen of the air with the iron. And yet pure dry air has little effect on dry iron. White vitriol (sulphuric acid) absorbs water very rapidly from air. In a bottle containing white vitriol a bright iron wire may be hung from the stopper (air-tight stopper) and will, one may say, never rust so long as it does not touch the acid. On the other hand, water without air does not rust iron. A piece of iron shut up in a sealed glass tube containing water whose air has been driven out by boiling, never rusts, if the conditions above are properly fulfilled. By rust red iron rust is intended—not simply a dulling of the lustre of bright iron. Bright tools may be kept for a long time in water in which carbonate of soda remains dissolved. We may say, therefore:

(1). Air alone does not rust iron.

(2). Pure water without air does not rust iron.

(3). Air and water alone rust iron slowly.

What is needed for rapid rusting? The presence of some acid. Carbonic acid does exceedingly well. Professor Calvert, of England, made a very long study of the rusting of iron. The following were the results of experiments lasting a considerable time:

Dry oxygen and iron	No rust.
Damp " " "	In three experiments only slightly rusted.
Dry carbonic acid and iron	No rust.
Damp " " " "	A little white carbonate of iron.
Dry carbonic acid and oxygen and iron	No rust.
Damp carbonic acid and oxygen and iron	Very rapid rusting.
Dry and damp oxygen and ammonia and iron	No rust.

For rapid rusting, therefore, we need (1) air, (2) water, (3), carbonic or some other acid. The last is always present in the air, and rain brings down a good deal of it dissolved in the drops of rain-water.

Coal contains sulphur, and burned coal gives sulphur gas; coal cinders with water give some sulphuric acid. But the burning of coal especially gives large quantities of carbonic acid gas. We have, then, on the line of railroads and in cities a special cause of rusting in iron, due to the presence of carbonic acid from coal fires.

An examination, made at the Stevens' Institute some years ago, of rusted iron from two bridges on the Pennsylvania Railroad, showed in water from the iron, sulphuric, a trace of sulphurous, and a quantity of carbonic acid, besides chlorine; and the conclusion reached, after some experiments, was that the presence of carbonic, sulphuric and sulphurous acid was sufficient to cause corrosion, as, indeed, the over-head work of a bridge subject to smoke will show.

One of the over-head bridges, or, rather, over-head coverings (galvanized iron), of one of the New York elevated roads was found to need renewal twice in a few months.

Still, there is a more efficient agent for producing rust than even carbonic acid, to wit, rust itself. All rust (not having been roasted) contains water, especially all yellow rust. The rusting of iron seems to take place after this fashion :

Air.

From which iron takes oxygen and becomes :

Rust No. 1.—Iron and oxygen.

This process goes on until we have a combination like the following :

1. Iron and oxygen.
2. Iron and oxygen.
   Oxygen.

This is our common red rust, or, if there is much water in it, yellowish rust.

Now the iron underneath this rusty coat steals the last oxygen and becomes by the same process:

Red rust. {
1. Iron and oxygen.
2. Iron and oxygen.
Oxygen.

Again we have red rust. To make up for this loss of oxygen, the upper crust has been taking more oxygen from the air. And so the process continues, because the first oxide of iron (iron and oxygen) has a great liking for oxygen, and because the red rust easily gives up some of its rust to its neighboring particles just below, while helping itself to more oxygen from the air.

This process of rusting (rust causing rust) is quite peculiar to iron. Other rusts, on zinc and lead for example, do not give up their oxygen to the metal underneath, but remain

Zinc and oxygen,
or
Lead and oxygen.

To this peculiarity iron rust owes its power of spreading under tin, zinc or paint used as a protection.

There is one kind of iron rust (iron and oxygen) which does not spread in this manner, namely, the magnetic, black oxide, which is found on Russia iron and is produced by the Barff process.

Apparently the black scale (iron and oxygen) found on wrought and cast iron, falls off because of the formation of other rust under it. A distinction must, however, be made between this scale and the hard skin of sand, etc., found upon cast iron. If this be painted over immediately, or dipped into hot oil, it retains its hold, while the scale on wrought iron continues to fall off, after being covered with paint.

The whole difficulty in protecting iron by paint lies in the fact that no covering of paint of any kind will protect the iron from rusting by the action of its rust, either red rust or common black rust. There is no paint which will "kill" the rust: Paint can only water-proof iron.

THE RELATIONS OF PARTS OF AN IRON STRUCTURE.

The questions involved in the influence of one part of an iron structure upon another as regards rusting are too important to be passed over.

Engineer Clark, of the Britannia Bridge, observed that a pile of plates, in all respects the same as those in the bridge, had rusted so badly that they were swept away with a broom, the bridge plates bolted together in the bridge suffering meanwhile no corrosion. This led him to the conclusion that iron might be protective of iron through connection, and to test the supposition he placed two plates on the bridge, one bolted to it, the other insulated by glass. The insulated plate evidently rusted the most rapidly, but the experiment was brought to a close by an accident before time enough had elapsed for a thorough investigation.

In direct contradiction to this, Mulder gives it, as the result of observation, that small pieces of iron connecting larger ones suffer so severely by rusting that it is better to paint the small ones thoroughly and leave the larger ones bare rather than *vice versa.** The greater the difference between the size of the pieces the greater galvanic effect. He recommends, there-

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* He says if a platina plate be thus connected with two pieces of iron, the galvanometer shows a current is flowing.

fore, the dipping of nails and screws into coal tar in order to keep out all water and damp air which the galvanic action would quickly tend to decompose.

Here we see the electrical theory working in exactly opposite directions in the hands of two of the most trustworthy scientific men.

A recent experiment of Farquason's in Portsmouth Harbor shows that both may be right, and is, moreover, an evidence of the care needed in studying these questions.

Plates of iron and steel (each kind as nearly alike as possible) of the same size were placed under sea-water, couples of iron and steel being connected and other pieces left isolated. All remained in the water for six months, and when weighed each had suffered loss by corrosion as follows:

	Loss.	
	Oz.	Gr.
Steel connected	0	427
Iron connected	7	417
Steel	3	340
Iron	3	324
Steel connected	0	297
Iron connected	7	74
Steel	4	...
Iron	3	190
Steel connected	2	337
Iron connected	6	...
Steel	4	157
Iron	4	57
The three iron plates connected with steel lost	21	57
Isolated plates	11	137
The three steel plates connected with iron	4	187
Isolated plates	12	60
Connected plates iron and steel	25	244
Isolated "	23	197
It will be observed the total rusting is increased by contact about	9 per cent.	
The iron lost by contact with steel about (excess)	100 " "	

The isolated plates of iron and steel lose each about the same.

This would have been still more instructive if iron could also have been connected with iron and steel with steel in large masses, but as it is, no experiment made upon the rusting of iron is more suggestive, for, as Mr. Farquason suggests, and as has been shown by previous experiments, using polished surfaces, iron rusts unequally, and it is probable that one part of the mass, harder than the other, will be destructive of the whole.

Mallet, who many years ago investigated the rusting of different sorts of cast iron, reached the conclusion that chilled iron rusts most rapidly, and that the more homogeneous and closer grained and less graphitic the iron the less the corrosion.

We see, therefore, that it is quite certain that differences in hardness and in structure of different pieces of iron connected may result in the greater corrosion of one than the other.

Also that Mulder may be quite right when he says that it is better to paint the small connecting pieces and let the larger pieces alone than *vice versa.*

As to the other conclusion, that iron connected with iron is protective, there appears to be no certain evidence aside from the effects of the vibration to which such a piece may thus be subjected. It has been pointed out that a pile of rails or the rails in a side track rust much more quickly than rails in the main line. But all the causes of this difference have not been demonstrated. The first question to be settled is the amount of water *remaining* on each kind, and the amount of rust, also the mere physical effect of vibration as related to these. Certain only is the fact that vibration is protective against rust.

Connection with other Metals.—The question of connection with other metals is an important one in relation to the preservation of iron, and the question demands a closer study than we are here able to give it, for want of a complete set of facts.

Copper in connection with iron is very destructive; on this all who have investigated the matter are agreed. Professor Colton says that care should be taken that no copper comes into connection with ship iron.

Zinc.—Zinc by itself is one of the most durable of roofing materials. Prof. Max Pettenkofer was at the head of a commission which investigated the decay of zinc, and experiments on a zinc roof 27 years old showed that the rate of loss would destroy a roof one-fourth of a line in thickness in 243 years.

At a meeting of the Society of Engineers (English) many years ago, the following was given as the ages of zinc roofs (Belgian zinc) still in good preservation.

	Years.
The Cloisters at Canterbury	33
Portsmouth dock-yards	24
Great Western Railway Station at Rugby	20
Another railroad station	20
" " "	15

With galvanized iron the case is different; it is valuable only when the conditions and its manufacture are such as to keep a perfect surface of zinc. Clark condemns its use in all acid atmospheres, but advises its use elsewhere, and there is a mass of testimony to confirm this advice, but it must not be forgotten that the question of the thickness and perfection of the zinc covering is involved in any such conclusion.

Under water, experience with galvanized iron has been unfavorable. At first, zinc was supposed to be valuable as a protector to iron; but it was found that the protection was only partial, and not lasting. In some water gates in which zinc nuts were screwed over the iron bolts to prevent corrosion, the iron was attacked after three years. Nevertheless, above ground inquiry into the comparative life of galvanized and common telegraph wires showed the life of the bare wire to be 15 or 20 years, while galvanized wire of 20 years' age was found to be but still little worn.

It may be said, therefore, that zinc-covered iron is valuable in proportion to its perfect condition, and for those conditions in which this perfection of covering can be kept; an acid atmosphere is destructive as is also sea water.

Zinc and Paint.—The difficulty of making paint stick to zinc is, I think, of a different kind from that ordinarily supposed. Boettiger, who has studied the question somewhat, recommends the following as a valuable wash. Its purpose is to change the metallic zinc surface into zinc chloride and amorphous brass:

1 part chloride of copper.
1 " nitrate " "
1 " sal ammoniac.
64 " water.

The zinc surface is to be washed with this* and left for 24 hours, which will give a black surface on which one can paint, but which will probably shell off the iron in the liveliest manner when any spot breaks up. Mallet found that zinc added to copper in connection with iron increased its rusting 60 per cent., copper without zinc only 40 per cent. A better method

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*Wash thoroughly with pure water afterward.

is probably simply washing the surface with dilute muriatic acid. This, however, will result in white lead turning as yellow as you please, as a Boston man discovered who used this preparation on a zinc ceiling ornament.

What we need to know is, *why* the oil does not stick. This, however, we do not certainly know, and can only guess at. One reason is because the surface is very smooth, and when the oil dries up, as it soon does, the paint having nothing to hold by, peels off. Another reason appears to be that the zinc does not unite with the oil acids, and, in fact, exercises some injurious action upon them. We should recommend, however, a *firm* paint, such as given by mixing some lead with iron oxide.*

In conclusion, it may be said that the great value of both tin and zinc-covered iron plates lies in the fact that only in this manner can we place the plates in position free from rust. If we were able to place naked iron in the same positions as thoroughly free from rust, it is not impossible it would be better so to do, because paint will hold to such iron better than to zinc or tin, and we should avoid all galvanic action. The experiment has been tried of finishing plates simply painted, but the paint rubs off in transit, and any bare spot may endanger the whole plate.

Finally, it may be said that except in sea water, there is no evidence of injurious galvanic action between iron surfaces and metals used with and covered by oil as paint.

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*The experiment may also be made of adding a little not-drying oil to offset the excessive loss of these oil acids, which keep the paint layer pliable and prevent over-drying.

CHAPTER XIV.

PAINTING IRON.

It is plain, therefore, by the facts stated in the last chapter, that we must discriminate in painting metal as to what we shall do in the way of preparation. It will also become evident that it is well to discriminate in the choice of our paint.

Cast Iron.—Cast iron does not rust rapidly, but in salt water softens and become a sort of plumbago. It should be painted or dipped in hot oil as soon as it leaves the mold, in order to preserve the hard skin before it is acted upon by the air.

If rusted in the least, the rust must be removed by scraping or brushing with wire brushes.

Wrought Iron.—The black scale or rust on wrought iron must be removed. It is not necessary to remove all the black scale, and indeed it is a very difficult thing to do. Mulder (who investigated the painting of iron for the Dutch government) found that a piece of iron from which he had with great difficulty removed this scale rusted quickly, while the piece on which the black scale had been left was quite free from rust. One will often observe pieces of old wrought iron quite clear of rust from no other protection than this scale.

We know that the scale itself is of different kinds; that produced by superheated steam, for example, being, as we have said, the best and only sure protection, while the ordinary scale to a large percentage gradually falls off, from (apparently) the formation of a minute quantity of rust powder under it.

It is worth while, therefore, to study the varieties of this (black) scale, for there is without doubt a difference between that formed in the ordinary conditions of the air, in water, under the beating hammers, etc. This study we must, however, leave the reader to make for himself, warning him only that all ordinary scale (black) is of an unreliable character, in the fact, apparently, that it can give up oxygen to the iron beneath it, and so form crumbling rust of the stuff by which it is held to its bed. It may be painted, and the paint will hold fairly well for a time, if undisturbed, yet, when the paint is scraped the scale will come with it; and this is a method sometimes used to get rid of it on ship iron. A light coat of paint is put on, which, after a year, is scraped off, carrying the scale with it, and leaving a solid surface for permanent painting. The scale may be removed in several other ways.

(1.) It may be allowed to rust off, and the iron may then be scraped with wire brushes. The objection to this method is the same as that against allowing your garden to get full of grown weeds in order to pull them with ease. In either case your antagonist may prove too strongly planted.

(2). The iron may be pickled in a bath of 1 part of sulphuric acid to 100 of water; or washed with a solution of 8 parts of acid in 100 of water; after which well scraped with wire brushes, and rewashed with lime water. Acid is only allowable where it can be thoroughly neutralized with lime water.

It is the practice of the Cincinnati Southern Railroad, to whose experience we shall refer, to have its iron treated with hot oil as manufactured without mixture with pigment of any kind, no paint being used for some months after the erection of the bridge; and then a coating of red lead.

When no attempt is made to remove the rust or scale, these must be mixed with the oil in putting on the paint, as well as that can be done with a brush. The object is simply to coat the rust with oil so that it will not be in contact with the iron, and is effective of course only with the loose particles.

Steel.—Recent English experiments on steel (using a galvanometer) give evidence that the "pitting" of steel is partly due to the galvanic action between the black scale and the body of the steel.

I have not seen the records of the original investigation, but Mr. White, of the Admiralty office (*Journal of the Iron and Steel Institute*, 1881) says:

"That was not a speculative belief, but a belief based upon experience and many careful experiments made under water in Portsmouth harbor. The trials were made with the greatest care under the most varied conditions, and the results made it as certain as one would be certain about anything that the black oxide, if left on portions of steel plates, would cause pitting on the bared surface of the plates. Active galvanic action could be traced with the galvanometer on the parts of the plates from which the scale had been removed. There was all the difference in the world between corrosion and pitting * * * as the Admiralty experiments proved. Mr. Parker had shown that there might be practically no corrosion on clean surfaces (steel) during very long periods, but if a hole was formed in the plate by pitting, it became a serious matter. In the Royal Navy they were trying to get rid of the black oxide by means of pickling before being worked; * * * plates were also being dealt with by a * * * process which had not been perfected. * * * In the private trade, where ships were built in the open air and exposed to the weather, he believed there was less difficulty in getting rid of this scale than in the case of the Iris and the Mercury. Great care had been taken * *, but when the Iris had been on service in the Mediterranean a few months, it was found that the effects of the scale were visible."

In the paper referred to by Mr. White, Mr. Parker says:

"We have, at the present time, 1,100 marine steel boilers running, * * * and the accounts I have received down to the latest go to show that steel boilers behave in respect to corrosion about as well as iron boilers. Greater irregularity in the corrosion of the steel is reported, and I am inclined to the belief that this is due even to a greater extent than in my experiments to the unequal action of the scale, and if it should be found necessary to remove the scale, the difficulties in the way would not be great, and much irregularity and pitting would doubtless be removed."

Priming Iron.—Having rid the iron of all but fast-hard rust, the question of a priming arises. Nothing can be done by any paint except water-proofing. Paint can have no influence on iron except to rust it by acids, or else to keep its surface free of water. The chief thing is to get the water-proofer to stick. (1) On smooth iron surfaces, oil loses its soft, not-drying acids and dries up; on rougher surfaces, it holds to iron quite as well as to wood, but (2) on all surfaces with black scale, the scale may leave the iron and carry the paint with it. Besides, there are only two other difficulties in painting iron. (3) The rust may spread under the paint from any point. (4) The paint which will stick to the iron best will most readily crack open the coats above it.

These are the chief difficulties, but Dr. Wiederhold maintains after a considerable study of iron surfaces that there is another one, which he apparently regards as the principal one. He claims that unless the priming color dries quickly, or if turpentine is used, the cooling of the iron (as at night or by the rapid evaporation of the turpentine) causes a deposit of dew-like moisture upon the paint. This moisture forms an "emulsion" with the paint, and it does not dry into a homogeneous mass. His idea seems to be that paint drying under the influence of water on its surface leaves little holes to the iron, or else that it more easily peels. I am unable to give the value of this result, but do not, myself, have any great confidence in it, but give it as the conclusion of one who claims to have made a study of the subject. I have not observed the rings (caused by drops of rain on fresh paint) to be centres of rusting.

Taking up the last difficulty (4) first, we find that cracking of paint on iron and the wrinkling and roughing up of paint come mainly from too thick a coat. Nothing will stick to iron better than boiled oil, because it is when dry, (*a*) firm, but (*c*) soft underneath, (*d*) elastic, so that it holds together well. The objection to it, however, is that it is too thick—it leaves so thick a covering that it wrinkles it, and may crack any over coat.

Painting Cast Iron.—Cast iron usually has such a rough surface and so many pores that there is no great difficulty in making paint stick to it, if the rust does not get planted underneath. When such an accident occurs the only remedy is to scrape off the paint and rust at that point, and repaint the spot.

It seems to the writer that it is for want of this distinction between the condition of the surfaces of irons (cast and wrought iron) that there is some confusion of views about methods of protecting them. Both have this difficulty, which no paint of any kind can overcome, that the rust spreads from any point under the paint. On both (exposed to the sun) the hot iron and the sun combined drive off the not-drying oil acids which keep the dry paint soft; the paint layer becomes hard and brittle.

Here, however, the two surfaces differ. The cast iron has a rough surface, and if promptly and properly painted is not inclined to scale. The scaling of the black oxide from the wrought iron carries the paint with it. Wrought iron needs a paint hard and elastic, which will hold itself together even if points of scale give away underneath it : *hence the value of red lead on wrought iron ;* while on cast iron, other paints, iron oxides for example, will serve quite as well. The following experiment was made under the auspices of the Dutch State Railroads.

Iron plates were prepared for painting, as follows :

Sixteen plates (Nos. 1 to 16), pickled in acid (hydrochloric), then neutralized with lime (slacked), rinsed in hot water, and while warm rubbed with oil.

Sixteen plates (Nos. 17 to 32), were cleared of scale (so far as it could be removed) by brushing and scraping. Four plates from each set were then painted alike, for example, Nos. 1 to 4 and 17 to 20, with coal tar ; Nos. 5 to 9 and 20 to 24 with iron oxide A ; Nos.

10 to 13 and 24 to 28 with iron oxide B; and Nos. 14 to 16 and 28 to 32 with red lead.

They were then exposed for three years with the following results:

Paint.	*On scrubbed plates.*	*On pickled plates.*
Coal tar.	Quite gone.	Inferior to the others.
Iron oxide A*	Inferior to other two.	Holds well.
" B	Superior to A; inferior to red lead.	"
Red lead.	Equally well on both, and superior to all.	

It is seldom that we can obtain so clear a record covering so long a period as this; but how shall we explain it; what, in other words, are the differences between the surfaces and between the paints? Pickling takes off quite all of the black oxide; scrubbing does not. Red lead unites with oil to form a hard oxy-linseed-oil-acid soap—a harder soap than given by any other combination. Says Mulder, of boiled oil and iron oxide, boiled oil and litharge, boiled oil and zinc white, and boiled oil and red lead: "The lead, when dry, contained the largest amount of oxy-linseed-oil-acid lead, and was harder than the others."

It seems to me, therefore, that the best interpretation of the facts is the simplest, namely, the difference in the plates is the scaling off of the black oxide on the scrubbed plates; the difference in the paints, that the red lead did not give way when this scaling occurred, because it is a hard, elastic layer of paint, which holds itself together by its own cohesion.

Further Testimony.–This result in the above experiment was not, however, exceptional. The testimony to red lead is almost universal.

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*From an analysis of this paint, it is probable that it contained more clay than the other.

The Cincinnati Southern Railroad has a number of miles of iron trestle work and bridges and has therefore furnished a large experience in the use of paint as protection for iron, the results of which may be summed up as follows:

Red lead has proved by far the best and most lasting paint. It is difficult to obtain in purity and is more expensive than iron oxide, but so much more lasting in the climate of the region through which the road passes that it is used in preference. The iron oxide is washed away by the rain and perishes in spots, endangering the iron; and yet nevertheless is a valuable paint if frequently renewed.

The standard paint for bridges on the Pennsylvania Railroad is white lead and a little yellow ochre, overheads being coated with asphaltum on account of the color and greater durability under the effects of the smoke.

Prof. Henry L. Colton writes to the *Scientific American* that after three years' experience, with unlimited resources for experiment at his disposal, he finds nothing equal to red lead for ship iron.

An instance comes from England of pump-rods, in a well 200 feet deep, which had stood forty-five years painted with red lead. At the expiration of that time their weight was found to be precisely the same as when new—no loss by rust.

Nearly every country of the world can furnish testimony of the same kind; but some people must have a thing happen in their own backyard with nobody by to make an exact record, or else, "it's all theory."

Disadvantages of Red Lead.—Red lead is adulterated with brick dust and other substances, and in this way has lost, perhaps, some of its good reputation.* Its value is that it unites with the oil, giving up at the same time a part of its oxygen. No other substance which does not unite with oil can replace it. Its value is its effect on the oil acids. Partly on account of this effect, it is said at times to blister badly. Spon says that should chemical action commence, red lead blisters, and is reduced to metallic powder. This is possible,† and it is also probable that red lead under great heat will blister sooner than iron oxide paint; and part of the reason is plain: it is more elastic. Elasticity in paint, as we shall show in another article, comes from the not-dried-up oil acids.

Red lead has also been accused of forming a battery with iron, and rusting the iron faster by unlinking the oxygen in water (see last article).

No evidence within my knowledge as to the effects of dried red lead paint upon iron has appeared except as to the effects upon two vessels, and on these below their water line. The paint on the hulls of the ships "William Fairbairn" and "Guienne," painted with red lead, was found (under the water line) blistered, and in these blisters were metallic lead and chloride of iron from the effects of the battery made by the lead and iron on the sea water.

But Jouvin, who reports the case of the "Guienne," says that above the reach of the sea water wherever the red lead was in good condition it had done no injury. In fact, we cannot be sure that even in this

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* In Europe it is also adulterated with colcotha (English red), made from refuse iron in the manufacture of sulphuric acid, and therefore quite certainly contains sulphuric acid, which would of course be very injurious to the painted iron.

† A master ship painter of very large experience tells me that blistering does not take place unless the vessel is painted while wet, or its iron more or less covered by scale.

case all the trouble may not have come from painting the vessel while wet. Our government vessels are painted with red lead and zinc; but the favorite paint for ships' bottoms in the merchant marine is, I believe, red lead alone. Red lead gives with zinc a very hard paint. Red lead softens tin, and has been accused of eating holes in it; this is not probable. It should not, however, perhaps, be used on tin. The tin of a cup containing red lead paint can be easily scraped with a knife, its surface coming off in thin "shavings."

Finally, the color of red lead is not durable, especially not with white lead. Under the action of the sun it becomes less orange; and mixed with other tints, or under the influence of sulphur gas, its color is fugitive. Again, red lead is perhaps more injurious to the workman than other paints, because he must mix it with oil as it will not keep for use ground with oil. The safety of the workman against the poisons which he uses lies in cleanliness and ready-mixed paints. The iron oxides should be preferred where they will serve equally well.

COAL-TAR AND ASPHALTUM.

Coal-Tar is largely produced in the manufacture of illuminating gas, the crude flying constituents of coal being driven off by heat and passed through water where the oily impurities of the gas are condensed as coal-tar, the partly purified gas flying away. Coal-tar distilled gives light oil,* dead oil and pitch. Pitch gives artificial asphalt.

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* Light oil is divided into "first light oil" and "second light oil," which together form crude naphtha, which redistilled gives commercial benzol. Mulder's benzol is probably crude naphtha.

Asphalt, as a natural product, is a limestone impregnated with bitumen or asphaltum, which resembles coal-tar.

When speaking of asphaltum, one may signify either (1) the rock in its original state, or as mixed and prepared with other substances as a paving material or cement ; (2) or the 6 or 7 parts of asphaltum obtained by boiling the limestone ; or (3) coal-tar pitch in either its crude or its purified state or mixed with other substances, or the coal-tar itself mixed with lime and sulphur, etc. Altogether there is a delightful state of uncertainty about the word.

Practically the difference between the crude asphalt (rock) and any manufactured article appears to be the better incorporation of the resinous and oily bitumen with the limestone, so that it is less brittle and more elastic. In addition to this the true asphalt (distilled) appears to hold fast an oily substance which escapes from the manufactured coal-tar.

The natural asphalt has a more glossy fractured surface, and as cement or paint does not so quickly soften under heat. Coal-tar is very brittle at the freezing point of water, true asphalt is tough at 10 degrees lower ; coal-tar softens at 115° F.; true asphalt does not soften at 170°.

Coal-Tar Paints.—A chemist who has studied asphalt has likened it to amber, and for practical purposes we may regard both coal-tar and asphalt (2) as consisting of a resin and an oil.

Mulder experimented with various preparations of coal-tar, and the following are the results of its drying as shown by weight. No. 1 is a coal-tar compound of the more resinous part (remaining after distilling off one-half the substance) dissolved in the lighter oil (number one).

DATE.	No. 1. Resin and light oil..	No. 2. Coal tar varnish...	No. 3. Coal tar and turpentine.	No. 4 Coal tar and benzol...
20 April....	1.248	3.856	2.787	2.323
... .	Lost.	Lost.	Lost.	Lost.
22 "	0.293	0.325	0.462	0.363
23 "	0.003	0.045	0.025	0.040
26 "	0.015	0.116	0.056	0.061
30 "	0.002	0.066	0.042	0.042
In 10 days.	25 p.c.	14 p.c.	21 p.c.	22 p.c.
26 July. ...	.028	.209	.157	.133
In 87 days.	2 p.c.	5 p.c.	5 p.c.	5 p.c.

It will be seen from the above that these varnishes are constantly losing in weight—the above experience was not in the sun, where the loss would probably have been greater.

No. 1 and best produces a harder and more brittle varnish and continues to lose substance—two per cent. in weight in 87 days. No. 2 is much longer in drying and is not hard after two weeks. No. 3 much the same as No. 2, and No. 4 is even less dry after two weeks.

Practical Experience.—The difficulty with coal-tar asphaltum as paint is that when hard it is brittle and when not too hard it has a tendency to flow, and will not therefore stand either the heat of the sun nor the diffused heat of summer. So long as it will stay, however, as a perfect covering it is perhaps the best, or one of the very best, of paints for iron. If put on hot, it enters all the "pores" of the iron and from its nature as a loose fluid-like compound keeps an immediate contact with every point of the surface. On locomotive smoke-stacks it dries hard, and, occasionally, bits of it blow into the eyes of the engineer. Even on underground pipes it has a tendency to flow, and for this reason, as shown by the experiment in above, it is probably less reliable for iron than iron oxide paint. It has its value, however, and may be said to be still on trial.

Mulder recommends it as perhaps the best protection for iron if not put on too thick, but his climate is not ours; and even in his climate, as we have shown, it proved on a fair trial less lasting than red lead or iron oxide.

An engineer of large experience with bridges tells us he regards asphaltum as a lasting paint, but as manufactured has proved to be brittle, tending to scale.

It is much better adapted for damp places than oil paint, because the air of such places often contains ammonia, which makes hard oil-leather fluid. For this reason alone, and for cheapness, it is well fitted for a covering for pipes, and it is the best paint for iron under water. It should for this and all other purposes be applied, if possible, to the iron while it (the iron) is at a red heat. If this cannot be done the asphaltum may be heated, but this method is less reliable unless the iron can be dipped in the hot fluid. Dr. Angus Smith's method for iron pipes is well known; the pipes are cleared and heated to 700° and then dipped into a mixture of coal-tar pitch containing 5 or 6 per cent of linseed oil.

Matthewson (Works in Iron) recommends it, under ordinary oil paint, if so desired, in the following formula : 30 gallons of coal-tar, fresh, with all its naphtha retained ; 6 lbs. tallow ; 1½ lbs. of some resin ; 3 lbs. lamp-black ; 30 lbs. fresh slacked lime finely sifted, mixed immediately and applied hot. He claims a special advantage for the paint in the fact that, being black, any worn spots on a white or light coat of oil paint over it would soon be perceived.

Its tendency as an undercoat would evidently be, however, to crack its oil leather over-coat.

CHAPTER XV.

PAINTS FOR IRON AND FOR GENERAL USE OUT OF DOORS.

Although we have already entered into details as to the qualities of paints, considerable remains to be said about their use out of doors, especially as regards protection of iron, as well as regards their use in finer and decorative painting, which will be fully treated of in part second.

White Lead.—White lead is so much used for painting iron that we should be able to give some definite experience in regard to it; yet we cannot. It is supposed by many painters to rust iron, and yet one of the most observing painters that we know is of the opinion that (judging from experience) the chances are even that the greater appearance of rust under white lead on iron is due to the greater contrast between the rust color and the white lead.

Theoretically, of course, as white lead contains carbonic acid, it is able to rust iron rapidly, on the supposition that the carbonic acid separates itself from the lead. This it is supposed to do when, on painting a black surface with white lead, the black surface after a time shows through the lead color much more plainly than at first.

All that can be said, so far as any facts are concerned, is that white lead should not, if possible, be used in priming iron, nor in any priming coat. Moreover, it is a less desirable over-coat than iron oxide. It probably, however, equals zinc in durability, and exceeds it wherever, as on railroad bridges for example, the paint is exposed to acid gases. Zinc is very quickly affected by acids, as is also the white lead as a compound of carbonic acid, the carbonic being driven off and the whiteness of the paint as well.

Stevens, the very best authority on house painting, writing after years of experience, recommended its use for town and city houses because of its stability of color.

Pure white lead and pure zinc are here referred to, while as a protective coat for iron neither should be used pure. The powdering of white lead has already been discussed, and the experimental evidence as to its cause gets the strongest practical proof from outdoor use of white paint. Nearly anything mixed with white lead will greatly improve its durability. Even a very minute percentage of Indian red and lampblack shows its effect plainly when we compare the durability of the pure white paint on the clapboard and the mixed paint on the moldings of a house. The one will generally be found after a couple of years (according to the exposure to the sun) to be in the condition of a whitewash, while the other and hotter color will powder off but little.

Unmixed white lead should never be used as outside protection, unless its color is very much desired.

Something should be mixed with the lead to prevent the effect produced by the carbonic acid lead on the oil. The oil is emulsified (separated) in some way, as into finer drops, and the mixture of almost everything with the white lead tends, apparently, to overcome this effect, whatever its cause.

The writer does not pretend to be able to say whether this change is chemical (change in the oil acids), or physical (change in the condition of the oil). Either change might account for the facts.

If a mixture of white lead and oil dried on glass, or a mixture of white lead and oil be examined under the microscope, using a high power and passing the reflected direct sunlight through the layer, an optical effect is produced as though the portions not covered by the lead, but centering around each separate particle, consisted of minute drops. Working with direct sun-rays and through glass is productive of optical effects which are uncertain as to their cause, but the appearances in this case are very distinct and may occur under the same condition in other pigments, in which case the size of drops should be measured.

The precise effect of the lead on the oil, however, is of less consequence. The facts in the case are: (1) that pure carbonic acid lead unmixed with the oxy-hydrate produces with oil an emulsion and not a paint; (2) that only a mixture of 25 per cent. of oxy-hydrate lead brings it to a drying-hard condition; (3) and, although our white lead usually contains more oxy-hydrate than this, it is still improved by substances which do not affect the oil as does the carbonic acid lead. Finally, the oxy-hydrate tested alone unites with the oil with a rise in temperature, showing true chemical action.

White lead is not a whitewash, only because it contains a little water-lead (oxy-hydrate) which chemically unites with the oil. It is probable, therefore, that by increasing the amount of soap (water-lead acts by forming a soap) we still further improve the lead, although necessarily by loss of its purity of color. If a white color is a necessity, a mixture of zinc white and white lead is to be recommended, but it will be well to use a little drier with the paint. If purity of color is essential, care must be taken that the zinc contain no sulphuric acid, as this will attack the lead; zinc from ores containing sulphur combinations contains small quantities of sulphuric acid.

Almost anything will improve the carbonic acid lead. Even the lower grades of white lead, which, as we have shown, contain a good deal of barytes, zinc and lime, are thought by some to stand quite as well as pure lead. It is hardly necessary to say, however, that no such combination is to be recommended * except to illustrate the fact that almost anything with pure white lead is an advantage, wherever the paint is to be exposed to *the sun.* "The weather" alone has no very injurious effect on the lead unless the sun gets at the paint, but after the sun has shone for some months the rain and storm can beat off the lead as though it were only lime. It shows the need of thorough investigation of these questions that this effect has been accepted by painters of considerable chemical knowledge as the result of the chemical combination of the lead with the oil, while it is only because of this combination by less than one-third of the lead that the paint holds at all.†

White lead is graded according to covering power, whiteness and fine quality; we cannot say positively, that a first grade contains more water lead than the others, but this is probably the case, and second and

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*Rose has shown that sulphate of barium (barytes) is acted upon little by little by water, sulphuric hydrogen gas, and possibly sulpuric acid, separated. Hunefeld has shown that sulphate of lime is decomposable under ordinary circumstances by the galvanic action of two metals in contact. Both barytes and lime, therefore, can give off acid under the conditions to which paint is exposed.

† For these facts we are indebted to Messrs. Wigner & Harland, of England, who have done more recent work on white lead than any other chemists.

third grade leads are not to be relied upon, even if the lead has been properly corroded, they may be adulterated. By this, we mean that they *may* not give so long a service. We have no experience with different grades to record; indeed, an experience of length of service, which is definite and of value with varieties of paint, is much more rare than should be the case.

Iron Paints.—These are of two classes and many kinds. In the first class are the artificial iron paints, which are commonly made from copperas and from refuse iron from the manufactories of sulphuric acid, dyes, etc. These contain more or less sulphuric acid and are never to be used on iron as a first coat, nor as a second coat if it can be avoided. They are of higher price and in a variety of colors, and only as colors would there be any temptation to use them.

The second class of iron colors consists of ores of natural iron rust combined with clay or with some forms of silica. Their value for iron depends upon the fact that they contain no water and no sulphuric acid. If there is water in these rusts (paints) they will act upon the iron as common rust.

From 70 to 50, and even less, per cent. probably consists of oxide of iron, the remaining 30 to 50 per cent. being of clay and other substances. The question of this substance, therefore, becomes important. Clay has a strong liking for water, and if not soaked with oil will possibly take up and hold a load of moisture. On roofs this is of less consequence, since tin is not itself rusted by such moisture. Here plenty of oil will be used, which the clay will soak up (ochres soak up 75 or 80 per cent.), and this oil will be protected from the sun and the air. Probably for this reason such pigments as Spanish brown are so admirable for roofs.

On iron, however (perpendicular surface), less oil will be used, and the clay, less well protected by oil from water, will be in danger of giving our water-proof layer a moist character. Unfortunately, there seems to be no exact observation, as there is no exact knowledge of the composition of such paints.

"What is generally called iron oxide is generally a clay (or chalk) colored with — to — per cent. of iron oxide, and ranging from yellow to brown, in color, and in weight accordingly, the lighter shades being unaffected by the magnet. With this inferior material the oil is liable to be absorbed from the iron oxide and the whole to change color and peel off. But 'magnetic paint,' or pure iron oxide, is excellent as a protection for iron, it being sometimes impossible to scrape it off; excellent on woodwork. It is resistant of salt water. It stands sulphurous gases well."

Moreover, this dry and roasted rust (paint) does not act as a protection to the iron, but to the oil. So far as protection to iron is concerned, no paint contains any other protective power than that given to it by the oil, and only by hardening the oil and protecting it from the action of the air when it has once become sufficiently hardened has any paint protective influence on iron. It is necessary to lay down this prime principle in the strongest way, in order that we may choose our paint with a clear mind, not befogged with notions about affinities or "anti-corrosion paints." An anti-corrosive paint would be a paint of zinc, for instance, which should have such an attraction for oxygen as to cause the oxygen to attack and *destroy* it in place of the iron.

A zinc bar left in a boiler was found to have entirely disappeared, as was supposed, through its protective power over the iron from oxygen.

Ruolz found that zinc-covered iron rusted more rapidly than naked iron under all bare spots.

Elsner found that tin, iron and zinc together set up such a galvanic action as to crystallize the tin into thin plates which could then be rubbed off.

An "antacid" paint might be used, since iron without the aid of acid hardly rusts at all ; but since the amount of carbonic acid in the air is unlimited, we should require an unlimited amount of base substance to neutralize the paint ; and if the surface of the base substance were not in some way constantly renewed, one paint would soon act as it does usually, to wit, as a mere water-proofer for the iron.

At present all paints protect iron by inclosing it in a water-proof layer, continuous and impenetrable. The only question involved in painting iron is the durability of this impenetrability.

The sun injures the layer in two ways. If, says Prof. Max Pettenkofer, the not-drying oil acids are removed from freshly dried linseed oil by ether and etherial oils, an elastic caoutchouc-like substance remains, which by degrees is hardened and made brittle by the air, and in this condition easily separates into parts, or, in simple language, cracks open.

Says G. J. Mulder, there are two periods in the drying of linseed oil, the first of which only I have studied. The first period occurs in the early months, and leaves the not-drying part of the oil (20 per cent.) unchanged, only the glycerine ether being driven off and oil-leather (linoxyn) produced. So long as this period lasts is the covering always dry, but remains elastic. When the second period is entered upon, it becomes brittle. The first period lasts a longer time in lower temperature and out of the direct rays of the sun. Under these conditions the oil in drying always increases more in weight. In ordinary temperatures and in diffused light 100 parts of linseed oil become 111 to 112 parts, but warmed to 170°, 4 to 5 parts are lost. In the direct sunlight 100 parts of the oil gain less than 7 parts; oil dried in the sun and partly covered by the sun gained respectively 5 per cent. and 10 per cent., or a difference of 5 per cent.*

Or, in other words, a difference of about one quart of oil in 1,000 ft. of surface. This quart of oil is not-drying oil, which has been changed by the sun's rays into a flying-oil acid during the first three months. Now, supposing the rate† of loss to continue for 12 months, the oil on the 1,000 ft. of surface (20 quarts) would have lost about all of its not-drying acids (4 quarts).

Oil drying on the inside of the house would at the same time have lost almost no substance. By actual examination Mulder found that oil in the house contained after four months drying its full amount (20 per cent.) of not-dry acids, combined with 91 per cent. of tough oil-leather.

Here then are the simple conditions under which we must work in preserving iron by oil: We must prevent the drying part of the oil from becoming hard-dry; we must keep the soft-keeping not-drying acids from flying away in so great quantity as to reduce the oil to a brittle mass. To attempt these things is to work on a basis of intelligent facts. Putting aside all ideas of "affinity"‡ between this and

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* The figures are gross, and the calculation of percentage the writer's. Mulder means (he must always be taken as a whole book, not by texts), that the oil acids (not drying) still remain—are not as a body changed. See tables of oil drying.

† Of course the rate would decrease, because the hard surface layer would protect the underlying oil.

‡ Except as regards the galvanic action between metals decomposing water. There is also some evidence that iron is protective of iron by connection, but it is, to say the least, capable of two interpretations.

that paint and iron, the only intelligent questions we need ask about protection by any paint substance are: Does it contain any hurtful acid? Will it protect the elastic qualities of the oil (the drying and the not-drying acids) from the action of oxygen? How long will it do this, and what is its price?

Particles of paint protect oil in three ways:

1st. They cover the oil and by their own substance thus protect the oil drops from the sun, the air, and the storms of rain, sleet and dust.

For this purpose we must, of course, have substances which are not themselves affected by the sun and the atmosphere. Iron, lead, silicon and slate are not much affected, zinc more than other substances when acid is present in the air. Sanding the surface of paint is merely applying the protecting power of silex particles to the surface of the oil, and it furnishes a cheap and efficacious method.

Clark tells of a larch pillar in a damp situation, the cracked end partially destroyed at base, but the paint, which was sanded, is still perfect after 35 years. "Sanding," says Stevens, "if well done, will last many years and need not be repainted except to freshen the color or to change it, or for the purpose of cleaning off the stains from dust which may accumulate. The sand should not be the finest nor the coarsest; well dried and sifted into the third coat, if a new building, with a sander—the best are made like a grocer's scoop, with beveled part of perforated tin, the holes about 1-16 part of an inch in size, and should be made to contain when full about four pounds of sand * * * Machines have been used for sanding to a good advantage, but I prefer the more laborious mode of sanding, as I think the work will be better done by it, besides the machines are very inconvenient.

"The paint in which the sand is to be sifted should be mixed with nearly all oil, and be put on as carefully as if for finishing coats, and the sand must be applied while it is fresh and sifted against the surface as long as any appearance of the oil remains. The workman should examine carefully for any greasy spots and dash on the sand again before allowing the paint to dry or set, even. Care must be observed to keep the stretch, or the edge, always beyond or out of the way of the dashing or falling of the sand, for if the brush comes in contact with the sanded part, the work will be unavoidably disfigured or spoiled. Once sanding is seldom sufficient for a good solid look of the work; a second sanding, the paint should be a little thinner than for the first. These directions apply as well for wood as for brick work."—*Stevens Art of House Painting.*

In general, however, painters have preferred to mix the protecting substance with the paint.

The protection of such mixed substance is, however, greater, if the paint particles are very fine, and it is more perfect the more perfectly the particles are combined uniformly with the particles of oil.

For these reasons iron oxide paints should first be ground very fine, and then thoroughly ground for hours with the oil.

Care should also be taken that they contain no acid (as many iron ores do), and that the water has been thoroughly roasted out of them.

2d. There is a chemical combination between the oil and paint as soap, which is protective. Lead certainly (except carbonic acid lead), and probably iron and zinc, to a degree, unite with the oil, and hold fast the flying acids. It is very difficult to bring proof on every point, but it is probable that where no portion of the protecting substance unites with the oil, there is greater tendency of the paint to crumble. At least it is true that all substances used as pure paints have some soap-making powers, and wherever hardness is required soap must be had, or the hardness will be the over-drying of the oil, or the first step in decay.

The hardest soap is given by lead, especially red lead, and (3d) this hardness is a protection by itself. When a freshly painted car or carriage is placed in the sun it is injured, while the same vehicle may be freely exposed after two or three weeks' hardening. The harder the *immediate* surface, the less effect produced by the air and the sun on the oil underlying this hard layer.

We come now to the final question in regard to paint for iron, namely, price. I think it may be safely said there is no paint equal to red lead for wrought iron *not thoroughly clean of all kinds of rust.* For perfectly clean iron and for cast iron, iron oxide paint of good quality may be quite as good. This is quite certainly the cheapest paint.

This chapter is written to show the *elements* of a good paint, not to advocate the use of red lead. *Properly hardened* iron paints, all considerations in view, *should be among the very best for iron and wood—the violet-colored for iron, the bright red for wood.* (See Pigments, Part II.) Exceptionally, the more expensive and injurious red lead may be used alone. Iron and white lead make a like hard mastic (Seddens).

The Oil.—The value of a paint is its oil, and economy consists in purchasing good oil–the best and purest to be obtained. Adulteration will be advantageous in some cases, but it should be done for a purpose. On roofs 15 to 20 per cent. of fish oil will be an advantage, and on bridges which are not so frequently repainted, probably a little cotton-seed oil will do no injury.

The principle of adulteration is very simple : the more " elastic " the first coat the more durable, but the greater the tendency to crack the second coat. The weather coat should always be the more " elastic ' (containing more not-drying oil), but a man of judgment will discriminate.

The most elastic (in the true sense) of all oils is boiled oil, but it is too thick, and needs to be thinned with raw oil or with turpentine. A priming of such oil thoroughly dried will stick, if red lead be added, and if not put on too thick.

A little boiled oil *thoroughly* mixed with raw oil increases its elasticity, but probably increases the chances that the paint will wrinkle, pit and crawl a little, although if care be taken in the mixing and using, any such effect should be so small as to be imperceptible There is this strong reason for using more or less boiled oil, that the pigment—at least lead-pigment, will more thoroughly unite with and harden the oil, as boiled oil is partly composed of free linseed-oil acid, and we shall thus get more hard soap. At the same time we thus get a harder oil ; we always get with the boiled a certain quantity of oil rubber produced by the boiling, and which so long as it remains gives the oil a rubber-like elasticity. It must never be forgotten, however, that both the hardness and elasticity are purchased at the price of color, and that such a paint will certainly yellow—a fact of little consequence, however, unless white or delicate tints are to be used.

The evidence in favor of boiled oil is very clear in many respects. We shall take up the matter in another chapter.

CHAPTER XVI.

BRUSHES.

The qualities required in a brush are elasticity combined with firmness and softness. Elasticity is the prime requisite of all brushes; brushes for finer work require a great degree of softness. No available substances but the bristles and finer bristles (hair) of animals have these qualities.

Hog's Bristles.—Those of the wild boar of Russia are the best for two reasons. (1) The hair of Northern animals is longer than those of warm regions. (2) But the Russian bristles are superior mainly because the animals from which they are taken are much older. Our pigs are allowed to feel only one or two winter's cold before they become pork. The Russian pig, however, may see ten or fifteen or twenty winters, and in general the older he is the better his crop of bristles; they are longer and stiffer, the best Russian bristle being the "Okata," which is very stiff, and six or seven inches in length. The next quality, or Firsts, is of medium stiffness and four to six inches in length. The third quality, Suchoy, is from 4¾ to 5¾ in. in length, the fourth quality, "Seconds," being one inch shorter. The last two grades are known as soft bristles.

The finest of short bristles come from France, a very fine quality from the South of France, of which there is only a limited supply.

White bristles are much more valuable in the market, bringing one-third more in price. They have apparently no advantage over dark bristles except the greater difficulty of adulterating them. The white bristle has not only to be sorted out from the darker ones but they also require bleaching.

Many bristles, both white and black, are taken from the backs of Western hogs. These, for reasons given above, are a very inferior article.

The importation of foreign bristles is about 1,000,000 of lbs. They come from Russia, Poland, Belgium and France, and are all superior to our home production—good pork and good bristles are not found together.

In Russia, the bristles come from two sources: (1) Slaughtered animals. (2) From the woods and wilds, where they are found and gathered by the poorer and more shiftless class of the people. The boar sheds his bristles at least every year, if not oftener, rubbing them off at his favorite scratching posts. Here they are found, bunched and sold to dealers, who take them to factories where they are sorted and cleared from decaying flesh, etc. The brush manufacturer bleaches (with brimstone, etc.), combs, and sorts the bristles as to length.

Adulteration.—Bristles are adulterated with inferior American bristles and with "Tampico," a kind of grass, imported from Central America. This makes a harsh, brittle brush and is in every way an inferior substance to any kind of bristle. A grass from Florida is also used for shorter bristles. Tampico is of a dark gray or blackish color; the Florida grass white.

Bristle Brushes.—A prime quality of a bristle is its "flag"—*i.e.*, the division of the bristle on the end into two or more "fingers." The best older Russian bristles have several fingers in many of the "flags." The flag adds fineness to the surface, while the coarser body of the bristle gives elasticity and stiffness to the brush. A brush-maker of long experience tells me that by using always the same sides, so that the brush is worn chisel-shape (not stubbed to a point), the flag will split down the shank of the bristle as the brush wears away, and the painter will get the benefit of it for a longer time. At least, a brush should be worn oval or to a flat chisel point, never to a sharp point, such as is produced by constantly turning the brush in the hand. A "stubb" is a sign that a green hand is at the other end. There are those who object to very long and stiff bristles, because after being somewhat worn they throw and spatter the paint. A brush of medium length is the best.

Brushes are numbered 1-0, 2-0, 3-0, etc. No. 6-0 is a proper size for outside (house) painting, and it is well to bridle it about one-third down with twine, unwinding as the brush wears away.* Inside priming is best done with the same brush, well worn.

Finer Brushes.—The finest, softest and most elastic brush is made from the hair of the sable. A genuine sable brush, however, is very expensive, a small short brush (they are usually short) being worth about four dollars.

Fitch Brushes.—The next grade of brush is, perhaps, the best, genuine fitch. The fitch is a small animal like the weasel. There is but a small supply of such brushes in the market.

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* The brush should not be bridled too tight, or the paint will squeeze out and smear the hand.

Skunk Hair Brushes.—This unpleasant little animal supplies much hair for imitation fitch and even sable brushes. Badger hair brushes are longer and stiffer. Bear hair brushes are also used.

Camel's Hair Brushes.—These are made entirely from squirrel's hair. They are soft and fine, but lack elasticity.

The Use of Brushes.—This is so entirely a matter of "tact" that each man will find out his own best way. Not so always with the choice of brushes.

Copper-bound brushes are the best. Good brushes are always the economical ones.

The Care of Brushes.—Dry brushes should never be kept in a warm or dry place, as they are liable to shrink. Paint and varnish brushes should not be used dry, and never as dusters.

Paint brushes should be hung (*without touching bottom*) in water, from a wire or other frame, in order that the water may reach some distance toward (not above) the bridle. The bottom of the tub will soil the brush, for it is quite certainly dirty.

Varnish Brushes.—These should be kept in oil and turpentine or in varnish. Brushes used for *English varnish must be kept in varnish.* This will save a deal of "mystery."

Varnish brushes should be thoroughly cleaned from time to time in order to prevent their becoming "lousey"—*i. e.*, full of dry particles which fall from the brush into the varnish.

A good mixture in which to keep all varnish brushes (except those used for English varnish) is one-half oil, one-half turpentine.

Good Rules.—In beginning to varnish, work your brush well through a little varnish to get rid of its oil and turpentine, and set aside this varnish for other purposes—for "truck."

Striping and camel's hair brushes should be washed every day used, dried with a towel and drawn to a point. In this way the points may be preserved.

CHAPTER XVII.

PUTTY, PASTE AND GLUE.

Common putty is a poor article; at times whiting is so high that it becomes a very poor article.

Whiting is chalk (carbonic-acid lime) in very fine powder (it may be dried and put through a fine sieve to secure fineness). A good putty is made by mixing good whiting with linseed oil until the mass is stiff. It should be thoroughly mixed in a mixer, and also well rolled in order to break down lumps and secure the soaking of every part of the whiting with oil.

The mixture is a mixture of particles, and there is little linking together of whiting and oil as soap; nevertheless it is well to let the putty lie in a mass for a day or two "to sweat."

"Store" putty is an article of uncertain composition, it may contain barytes and other substances having an affinity for water, and which harden like plaster. It is said that water is often added to the whiting that less oil may be used, causing the putty to stick to the fingers, probably by the formation of oxy-linseed-oil acid and plaster. Such putty dries into a hard, brittle mass which crumbles.

Panel Putty is a superior article, made from whiting, white lead (in oil), japan (or varnish), and a small quantity of turpentine. The whiting is used merely to prevent the white lead from sticking to the fingers, and no more than necessary for this purpose is required. This putty forms a hard cement which does not shrink; and, when dry, it can be rubbed down with pumice-stone or dusted with sandpaper, so smoothly will it cut.

DRYING OF THICK MASSES OF PUTTY.

On April 2, the following mixtures were made, and exposed in mass. They gained weight as stated:

Boiled oil......	3.415 grammes.		4.594 grammes.
Whiting........	21.392 "	Litharge..	31.750 "
		Red lead..	34.314 "
By July 23 each had			
Gained....	0.029 grammes.		0.056 "
And lost........	0.019 "		0.006 "
Net gain........	0.010 "		.050 "
	0.3 per cent.		1.1 per cent.

The lead putty, treated with alcohol and chemically examined, gave a quantity of oxy-linseed-oil acid, which had evidently existed in the putty, linked with the lead as a

$$\overbrace{\text{Oxy-linseed-oil acid.} \qquad\qquad\qquad\qquad \text{Lead.}}^{\text{Lead soap.}}$$

The whiting putty, treated in somewhat the same manner, gave only (after removing the whiting) white, hard oil leather, which had evidently been *mixed* with the particles of whiting.

The lead soap gives by far the hardest putty; it is another evidence of that secret in making up a paint material, namely: *if you wish hardness, there must be a substance which will unite with the oil and form a hard soap.*

If a hard putty is desired, it is always well to use some white lead, even in the common sorts of putty. Boiled oil will also give a harder article, if the oil is good; and varnish is said to give a fine article.

RULES FOR USE OF PUTTY.

1. Complain of all large nail-head or screw head holes; it is in every way better to have the wood in its place than to fill a big hole with putty, which in a

mass is quite sure to shrink and let the water into the wood.

2. Fill all holes solidly full, leaving no air spaces, as these over nail or screw heads allow of rusting, the accumulating pile of rust pushing out the putty.

3. Use white lead putty. It is more than probable that as linseed oil dries, the flying oil acids may break up the whiting (which is carbonic acid lime), loosening the carbonic acid gas, which partly flies away, thus decreasing the *bulk* of the putty.

4. In glazing, sight the glass and put the convex surface on the outside, on the same principle that a watch glass is placed, both being stronger for the shape and for having the convex surface on the side exposed to greatest pressure.

Tallow may be mixed with putty for large panes in order to keep it pliable, allowing a certain play for the glass as it expands and contracts.

There are many recipes for putty—in fact, a little book full of them—and we give a few.

Glycerine putty is made of good thick glycerine and white lead or litharge ; it hardens in 15 to 45 minutes, and withstands water and acids. It is well to use it warm.

Water-Glass Putty.—This is made with water glass (silicate or soda) and zinc white, and is highly recommended as a putty for iron.

Putty for Porcelain.—It is not advisable to use any putty or cement made with lead *for any dish to be used for holding food or drink.* The following may, however, be used with great safety : Casein (made by adding a little acid to milk and removing the whey) dissolved in water glass. Casein dissolved in bicarbonate of potash or soda solution and gently evaporated to thickness, gives a good cement. Casein in a stiff solution of borax in water is superior to gum arabic in stickiness.

Paste is best made with rye flour, and is improved by the addition of a little glue solution, and may be preserved by adding alum. Hot starch paste may be improved by adding half its weight of turpentine. In preparing paste, beat up the flour in cold water, and then add boiling water, stirring rapidly. *For wall papers* use fine wheat flour, and be careful *not to use old paste.* Cases of illness have arisen from old paste or old size used with wall paper ; and where no illness is caused, a slight, unpleasant odor may arise from such paper when the room is closed. Alum may be added to paste to be used for flock papers. Half an ounce of rosin added to flour paste, and the mixture gently heated to the boiling point, and, on cooling, thinned with a solution of gum arabic, gives a paste which may be used for papering painted walls.

Glue.—If good, it is a hard cake, of a dark but almost transparent color, free from black or cloudy spots and with little or no smell. The more transparent and amber colored the article the better.

Inferior glue made from bones will almost entirely dissolve in *cold* water ; other kinds are contaminated with lime.

Prepare by breaking in small pieces, covering with cold water for 12 hours, melting in a double glue pot (covered) so that the glue is never raised to a higher temperature than that of the boiling water in the outer pot. It should simmer for a couple of hours, and then hot water should be added until the glue is just enough liquid to run from the brush. Glue is better for remelting. Apply hot and use as little as will serve, wiping the surfaces of the wood clean and dry before applying the glue. The strength of glue for common work is increased by adding a little common chalk.

Glue Size.—A pound of glue makes a gallon of size, but double size requires about twice this quantity. Size is made like "glue" as above, thinned to required fluidity with water. Patent size is a kind of gelatine.

CHAPTER XVIII.

THE EFFECTS OF PAINT ON HEALTH.

The painter often gets the colic and other lead affections ; the time of the development of the poison is from eight to fourteen days from the beginning of labor. Among one hundred laborers who have worked at their trade five years one finds at the most twenty-five who are suffering from no appearance of intoxication; in other words, seventy-five per cent. are affected ; these laborers are oftenest diseased by white lead. Tanquerel found among 1,213 cases of colic,* 305 painters ; among 752 cases of affection of the nerves, 168 painters; among 101 lead paralytics, 22 painters—numbers which show in general the frequency of the intoxication.

The *varnisher*† and artist-painter, who likewise use much white lead, suffer in general less from lead poisoning, as their labor is partly in the open air ; peculiarly certain is the metal varnisher (japaner) of lead intoxication, whereas the carriage and wagon varnisher, though not entirely free, seldom appears for treatment. Out of 2,161 lead-affected sufferers only 84 (=3.4 per cent.) were wagon varnishers, and 66 (=3.05 per cent.) artist-painters (heraldry, decoration and porcelain painters), which numbers, in comparison with laboring painters and all other users of white lead, seems favorable. Among lead-affected : 84 (74 varnishers), of 66 affected artist-painters, 36 from colic, and 33 varnishers and 25 artists from affection of the nerves.—*Dr. Ludwig Hirt, Specialist.*

Going further, lead poisoning shows itself, in the first place, by a very stange selective affinity for certain nerve trunks and certain muscles, and evidently on being absorbed it is deposited in the muscular substance and the extremities of the nerve filaments of these parts. The first muscles involved are almost invariably the extensor muscles of the forearm. In consequence of the paralysis

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* *Acute* effects : lead colic, acute asthma. *Chronic :* debility and loss of vigor attributed to "the liver," progressive paralysis and atrophy of the muscles, chronic contraction of the flexor muscles, loss of sensibility (paralysis), loss of voice, epilepsy, disease of the heart and kidneys.

† Probably refers to varnish manufacturers.

of these muscles, we have the characteristic symptom of wrist-drop. From the fact that this affection occurs frequently in painters, it was formerly believed that it affected these muscles because they were used more than the other muscles. This is not the reason, for we find that it affects the left side as well as the right, and that it makes no difference what the occupation is, nor how the poison is absorbed. It is not only the extensors of the hand that are affected. About ten years ago there was a remarkable case of long-continued lead poisoning under my care, which finally ended in death. The patient was paralyzed from the shoulders downward. After death I extracted lead from every portion of that patient's body. The lead, then, has an especial affinity for the muscles named, but when the saturation is extreme it will involve other muscles and other nerves.—*Dr. Wm. Pepper* (*Philadelphia*).

The painter, glazier and plumber, above every industry, are affected by the mentioned (lead) diseases, and we have therefore here collected the experience in regard to their health. Often, as in the English statistics, are these industries grouped. The result is as follows:

DEATH RATE PER 10,000 PERSONS.

AGE.	Painters, etc.	The whole people.	62 selected trades and professions.
15	36	63	42
20	71	86	83
25	94	98	97
35	166	130	133
45	278	185	196
55	487	322	350
65	930	668	756
75	1,800	1,658	1,922

Neison has the same class of men examined and with the following result:

AGE.	All trades.	Farm laborers.	Painters.
20, 30 and 40	2.37	1.85	4.07
50, 60 and 70	9.46	7.02	14.78

Ratcliffe's experience gives, in general, the following result :

AGE.	DEATH RATE.		ILLNESS IN WEEKS.	
	Actual.	Should be. *	Actual.	Should be. *
18	106	87.96	8,486	8,568
41	18	17.21	2,281	1,795
61	2	.85	69	105
	126	106.02	10,836	10,468

* On general experience.

In Finlaison's report the professional painter is separated from other trades.

AGE.	PAINTERS.		ALL ENGLAND AND WALES.	
	Death rate per 10,000.	Ill—Days.	Death rate per 10,000.	Ill—Days.
20	....	6.83	74	6.88
25	144	6.35	71	6.83
30	96	6.84	77	6.91
40	189	8.96	103	8.21
50	307	16.53	150	11.49
60	563	21.74	261	18.73
70	719	40.26	552	43.62

The death rate of the first table given is 21 per cent. above the calculated (from general experience). Italian experience seems to show the average frequency of illness.—*Harald Westergaard, Statistician.*

There are no available facts as to the comparative mortality and disease among American painters. Colic is probably infrequent, and the lead difficulties of a mild chronic form ; bilious disturbance from disordered circulation of blood through the liver, dyspepsia and increased tendency to constitutional diseases. The New York Hospital averages ten cases of lead poisoning per year—largely, probably, painters. This fact, however, has little value as to the home frequency of lead disease ; and the above remarks as to American experience are merely a guess at the probabilities. —*C. L. C.*

When I was requested to furnish some particulars of the more striking cases I have investigated for the Government I was astonished to find that during the last eleven years I had traced back no less than one hundred and twenty-three cases of illness attributable either to the diffusion of carbonate of lead (common white paint) or to arsenical or antimonial coloring matters in paint or on wall-papers.—*H. C. Bartlett, P. H. D., England.*

OFFICIAL (MINISTERIELLE) CIRCULAR CONCERNING THE SUBSTITUTION OF ZINC WHITE FOR WHITE LEAD IN OIL PAINT.

The manufacture and use of white lead have long been known as eminently unhealthy operations. The employment of the paint produces equally fatal effects upon painters. As regards its manufacture, certain recent improvements have reduced the danger to a certain degree of inoffensiveness, but these improvements are not always realized by manufacturers ; as respects its use it is true various precautions considerably weaken but do not entirely destroy its pernicious effect. * * * * A decree emanating from the Department of Public Works, of the date Aug. 24, 1849, prescribed the substitution of zinc white in place of white lead in painting all governmental works. Since then a commission, instituted by the same department in 1850 and 1851, composed of most competent men, have studied this question with special care ; they are agreed upon the dangers of the manufacture and use of white lead, and upon the necessity of replacing it by zinc white.

It is the conclusion of this commission that the manufacture, use and rubbing of the zinc white paint does not present a single danger to the health of the worker. Moreover, this paint has qualities of durability, solidity and appearance not met with to the same degree in white lead paint ; lastly there is to-day equality of price ; it is to be hoped that the zinc white will shortly be procurable at less price.

In view of these conclusions Monsieur (the Prefect), you will please take measures for the general use of zinc in painting the department buildings. An absolute exclusive prescription would cause inconvenient disturbance in the important manufacture of white lead, but it is essential, nevertheless, that a comparative trial be made on a large scale and the preference irrevocably given to that kind which experience demonstrates to be the superior from the double point of view of health and economy. You will give, in this sense, instructions to the architects in charge of the department buildings. You will also transmit the same to the *maires* of the communes of your department as regards the communal buildings * * * F. DE PERSIGNY.

Each time the commissions of savants, of chemists, of architects, etc., have studied the question, zinc white has been given precedence to white lead. But the custom is incurable; it brings forward in opposition a generalization of the art of painting. Custom has always one formula: *Zinc white covers less than white lead.* * * * It is in vain that Chevallier, that Tardieu, that the committee of Arts and Manufactures, that the Consulting Committee of Hygiene, etc., issue their advice, the sacramental formula is met, custom opposes it victoriously to all argument * * * and each year it kills hundreds of laborers and injures thousands.—*Dr. Henry Napias, General Secretary of the Society of Public Medicine* (*France*).

Except as coming in food and drink, there is but one way in which the community is apt to suffer from lead colors, while the manufacturers and the users suffer more or less severely in many ways. Fresh lead paint is not only very unpleasant, but possibly injurious to a greater degree than is supposed. The only experimental evidence seems to be that of a French painter who kept guinea pigs and other animals in freshly-painted cages for some weeks. They all suffered in health, but none died. Cases are on record of lead poisoning attributed to sleeping for a single night in a freshly-painted room; but they are too few and too indefinite to give any certain light. A popular maxim attributes danger of abortion to pregnant women breathing the air of such rooms, and has a fairly good foundation in the physiological development of such an accident. Cases have occurred in France of lead poisoning by cooking over fires made of painted wood ; the danger is no doubt very considerable ; indeed an order has been issued by the Police Department of Paris forbidding bakers to kindle their fire with such wood.

In general, however, the use of lead paint is an injury only to the painter and the manufacturer of the article. For the painter the principal difficulty arose in the grinding of paints, especially white lead, and since the introduction of keg lead it is probable that fewer cases of poisoning have occurred. Nevertheless, lead remains, as Napias calls it, the great industrial poison. Its insidious character as a poison is shown by an incident during the inquest on the body of an artificial flower manufacturer who died of poison. The firm placed on evidence as to the healthful character of the occupation a girl, whom the physician asked to open her mouth. There was the infallible sign of lead poisoning on the teeth and gums.

As will be seen from the above figures, it is the house and general laboring painter who suffers most.

The question arises, therefore, what duties do the general public owe him?

1st. It is also due to the painter that the use of *red lead* and all poisonous pigments which must be procured in powder, be avoided as far as it is possible to do so. The writer has shown the value of red lead as a drier, in giving a hard and durable layer of paint or varnish, but he is far from advocating its use as a paint, except in rare cases. Care on the part of the painter will at any time prevent any very serious effects from its use, but this care is expensive in thought and time, and moreover, will seldom be taken by those who most need its protection.

De Cartier (of Anderghem, Belgium), sends me a circular, from which I clip the following :

"By other experiments resulted the following estimate of the cost per square metre and per kilo., ground, of different paints, but we must remark that the wages of the workmen are not taken into account in these calculations:"

	Per square metre. Francs.	Per kil., ground. Francs.
Iron-minium*[*]	0.20	0.75
Red lead	0.40	0.80
Colcothar	0.27	0.70
Brown ochre	0.30	0.72
White lead	0.60	0.80

2d. It is due to the painter that zinc or iron, or other harmless substances, be used instead of lead where possible. The objection to zinc is that it covers only three-fifths as well as white lead. It is not blackened by sulphur gas, and it does not turn yellow. As stated in these articles, it is probably less durable in an acid air than white lead, as it has the tendency to flake and scale. Nevertheless, no one has ever measured its comparative durability. A commission, with Pettenkofer, of Munich, at the head, investigated the rusting of a zinc roof and found that it had lost only 0.00543 of *line* in 27 years. In other words, zinc one-quarter of a *line* thick would rust away in 243 years !

The difficulty—such difficulty as its tendency to scale—may lie in its relations to the oil, and be curable by mixture with some soap-making substance.

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[*] Iron oxide.

As it is, it will outlast long white lead in appearance inside the house, and perhaps equal it under ordinary circumstances outside. Again, our colored tints are largely made up from white lead, when there is no such necessity. For either wood or iron good iron oxides will last longer ; and on wood can be tinted by the sulphuric acid iron colors. The demand for white paint in the past has made lead cheap, and more of it is used than is economical, aside from the question we are discussing. The sulphuric acid iron ores produce, when roasted, a bright red pigment which is peculiarly adapted to exterior house painting. Throughout Northern New Jersey one sees abundant evidence of the lasting qualities of this color. After years of service it presents a fine house color, while mixed lead tints of brown, etc., appear sadly faded—where they are not sadly muddy. Finally, there are the new whites, combinations of zinc sulphite and prepared barytes, which cover better than common zinc, and are worthy of a fair trial.

The shortening of the lives and possible suffering to which painters are at times exposed come probably nearly all from lead paints. Turpentine vapors have been supposed to affect them, but the experimental as well as the practical (other trades) evidence is against this. The only injurious effect of the turpentine is upon the lungs, and not severe in the case of those constantly exposed.

Painters working exclusively in shops often become pale and debilitated, and suffer with lung difficulties, which may be due to breathing the turpentine vapors. American investigations have discovered no lead in the atmosphere of a room freshly painted ; and German investigations show that turpentine may affect the lungs. Varnish shops therefore have peculiar need of thorough ventilation.

The following are the main avenues of the lead into the body:

Avenue.	Substance.	Method.	Degree of danger.
Skin	Dry powder.	Gradually absorbed.	Very great.
Skin of hands	Paint.	Washed in by turpentine used in cleansing.	Very great.
Skin wounded	Powder or paint.	Direct absorption.	Greatest possible.
Mouth	Powder.	Lungs and stomach.	Considerable
Mouth (by the food)	Dust from clothing.	Stomach.	Very considerable

Effects of Poison.—Symptoms: Loss of weight (caused by loss of fat), coloring of the skin dead-yellowish to blue-gray, especially white of eye; also of the mucous membrane of mouth, especially marked on the gums and teeth, sweet lead-sugar-like taste in the mouth, and fœtid breath.

The effect of lead on the painter's body may be summed up in a word—he becomes partially *a lead soap.* The lead unites specially with the oil and fat of the skin, and with any fat it finds in the body. Alcohol drinking is terribly dangerous, because it produces a low grade of fat, which is quickly changed to soap, and because the alcohol itself stops the only outlet for the lead—namely, the kidneys. Difference in care and kidney makes the difference between painters.

The influence of alcohol may be illustrated by the following cases reported as being under special treatment in a foreign hospital; the cases were not selected at all with a view of showing cause of difficulty, and I give them as reported. These were all severe cases of lead colic, some very severe.

Jean Marchetti, no signs of the use of alcohol, constitution good, works in white and red lead.

Jérémie Bima, painter, uses alcohol habitually, color mixer.

Gaspard Redieu, decorative painter, evidently uses alcohol to great excess.

Jean Daglia, painter and manufacturer of varnishes, third attack.

Louis Arragon, painter, uses alcohol to excess, six months, color mixer.

Jean Polli, good health, no bad habits.

Jean Dedominici, painter, used alcohol in excess when a young man, drinks now very little.

Ferdinand Bruno, painter.

Pierre Vervack, painter, uses alcohol in excess.

Louis Valette, carriage painter, frail constitution.

Andrew Durand, painter, uses alcohol in excess.

Charles Ubertalli, no alcohol.

Antoine Bellicard, painter, suffered from fever.

Laurent Chambria, uses alcohol somewhat excessively.

Louis Roger, not a painter, but uses lead somewhat.

Pierre Servaz, painter, no alcohol. Had been rubbing varnish.

Antoine Charbonnier, house painter.

The effect of lead upon the system takes place apparently by means of a union of the metal with the fat of the body, forming a soap. This is not a strictly scientific view of the matter, but is borne out by many facts and is the view of one of the best chemists engaged in the manufacture of paint. Any lead left on the skin is dangerous, since it may unite with the fat of the body and so gain entrance into the blood vessels. If the skin be in any way scarified or abraded the danger is increased enormously, and laborers in white lead who withstand its effect for long periods may acquire lead poisoning in a short time from an injured surface. The effect of red lead is, apparently, upon the nerves, and there are fewer cases of lead colic by its use; in other words, it is an insoluble substance which, very gradually, affects the body; but it is the most dangerous form of lead, because not united with the oil, but commonly used by the painter in powder. The decrease in lead disease has probably taken place by the more extended use of lead in oil and the great adulteration of the lead by zinc and barytes.

White lead is to be used with care, the painter making it an invariable rule to carefully wash his hands without the use of turpentine and never to go home nor even eat his lunch, at the shop, clad in his working suit, which should be an oversuit. There is danger in clothes which have become smeared with lead, which gradually finds its way to the skin; and there is still more danger in particles of dry powder falling from such clothing into the food. In other countries, and perhaps in our own, the painter's family, especially his wife, suffers from the effects of lead, which probably in this way gets into the food and drink of the family. Dry powders are especially dangerous, because they more easily fly through the air; they also have a special effect upon the lungs, producing a peculiar asthma.

We shall give in the Appendix a note on the treatment of lead diseases. Previous to speaking of preventives it may not be unwise to obtain some ideas about the effects of the lead upon the body. These effects are upon the nerves and upon the muscles.

On page 185 is a set of diagrams showing the tracings of the pulse in *lead colic*, which illustrates the acute (sudden) action of lead.

No. 1 represents the normal pulse of a patient just recovered from lead colic.

Nos. 2, 3 and 4 are tracings of the pulse of three patients suffering intensely from this disease. Apparently the arteries are overfull with blood, due to contraction of the small blood vessels (capillaries, etc.) which connect the arteries with the veins. The small blood vessels contract under the influence of the nerves; the nerves are affected because they are partly fatty substance. The veins are more or less empty, the arteries severely congested and the pain suffered by the patient arises from these conditions indirectly. The colic is merely an accident, due to a sudden or a gradual accumulation of the lead in the blood. The lead has united with the fat* of the body and various causes may produce either a diminution of the loss of lead constantly taking place through the kidneys or an unusual quantity of the metal has been released from some part of the body.

In slow (chronic) poisoning the lead gradually destroys the health of the nerves and does not affect the circulation. But the essential point illustrated is, that hope of cure involves *keeping the lead out of the body.* Some persons (gouty persons especially, whose kidneys are not right) are more quickly affected by the lead than others. The painters' lung troubles are caused both by lead and by turpentine—*i. e.*, by impure shop air. His liver troubles are not improbably due to stagnation of blood in

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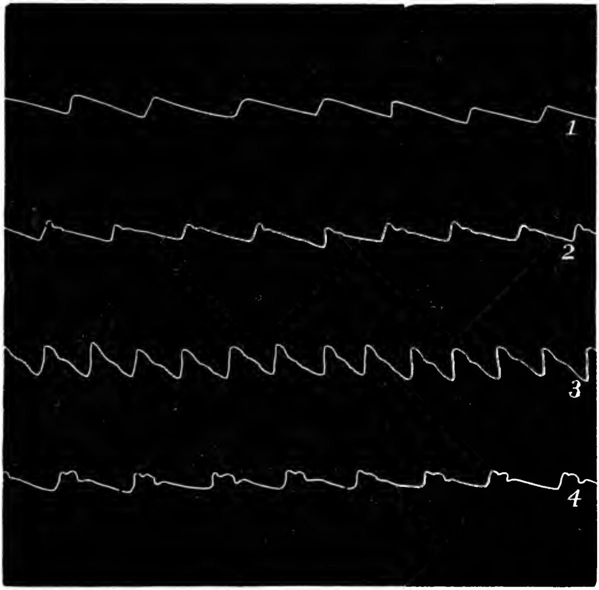
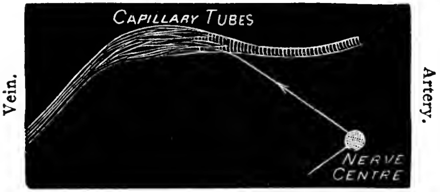
* The word "fat" is used as more familiar than the word albumen. The lead probaby unites with the albumen of the blood and tissues, and perhaps also with the fat.





EFFECT OF LEAD IN THE BLOOD ON THE CIRCULATION.

The break in the top of the written wave is due to a like cause to that producing the jerk in a water-pipe when the water is suddenly shut off by the faucet.

Long continued excess of meat in diet produces like conditions of a slight character.

the liver, and some contraction of its capillaries *only.* The cure is rather in the use of fruits than of purgative medicines, although an occasional dose (wineglass morning and night) of Hunyadi Janos will be of service. Part of our object in giving the pulse tracings of lead colic is to convince the painter that strong purgative medicines are not indicated nor does experience warrant their use. Preventive treatment goes upon the theory that the lead must be made as insoluble as possible in the stomach and as soluble as possible in the blood in order that it may be thrown from the body. Acid drinks, especially lemonade, and a very weak sulphuric acid* ade (great care being taken not to use too much of this poisonous substance) ; vinegar and the like, are adapted to this purpose.

But the greatest preventive of all is milk, which supplies the body with large quantities of fat as cream, easily taken up and used and replacing that destroyed by the action of the lead. In several white lead factories in France, colic has been almost entirely abolished by an extra allowance of a pint or a quart of milk per day to each laborer. The chemist, to whom we have referred and who represents the best practical opinion of Germany, advises the use of milk in the largest quantities.

It should not be forgotten, however, that no fluid, if possible, should be drunk in the shop or the manufactory or at any place where it is exposed to lead powders, floating as they will, in the air.

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* One (1) ounce of sulphuric acid to thirty-two (32) quarts of water. It is to be taken only by those exposed to powders of lead, and only while at work. A bath in water containing some sulphuric acid is also valuable.

Pure air in the shop or factory is of the greatest importance.

In closing, we urge all who have to do with this subject of paint, to take large and sober views of their duty to the common painter, who, more than any one else, suffers from its use. As far as possible, lead should be given him for use, ground in oil ; red lead he should as seldom as possible be required to handle. The lead should, wherever practicable, be reduced by zinc or be replaced by zinc or iron oxide, with which, however, some lead may be used to harden the paint. As far as possible, all the facts have been presented to the reader that he may decide these questions for himself, and it is hoped that he will share with us the feeling of responsibility for the health of the painter whom he directs.

There is also here an opportunity for the chemist to produce a substance which will unite with the oil, not be affected by water, and produce a hard and lasting paint without those disqualifications as regards human life and happiness, to some degree connected with lead, although a careful use of white lead *in oil* is less dangerous than many other practices of civilized life. Its careless use alone can be regarded as peculiarly dangerous.

PART II.

"*In order to insure good coach painting, and to enable a workman to attain success and the complete mastership of his business, five essentials are absolutely necessary—viz., perseverance, studious application, cleanliness, knowledge of chemistry, and experience—and if we add an acquisition of taste in design and harmony in the arrangement of colors, it would greatly tend to lead the way to a more artistic style of painting and decorating carriages than the conventional styles at present in use.*"—THE HUB'S Prize Essay on Carriage Painting.

PART II.

CHAPTER I.

LINSEED OIL AND THE PAINTER'S DIFFICULTIES WITH IT.

There are several methods of dealing with the subject of painting.

1st. The painter, if we may call him one, may take his brush and go to work, and keep at work, spending no thought or worry on any difficulty or over any job of whatever degree of badness. This method produces rough work and needs a tough skin, and a man who has no desire to rise in the world.

2d. The painter may study every difficulty he meets with, and out of his own head spin all sorts of theories to account for his troubles. Such a man often talks very wisely and does very poor work.

3d. The painter may study every difficulty of his trade with keen, observing eyes, not caring for any sort of theory or explanation, but doing his best to get over each in the shortest practical way. This requires the life-time of a truly able man; and when he has finished his observations he will find that many things are as dark as Egypt, for the reason that no mere observation will give a clear comprehension of the nature of oil, its changes and its relations to white lead and to other substances used as paints. Some of the ablest chemists of the world have studied those questions, giving months of patient investigation and bringing to bear all their scientific knowledge and apparatus in order to get an answer by test experiments. These results have had an influence upon the opinions and the work of intelligent painters throughout the world, although their knowledge has been of a general character and obtained by tradition rather than by study of the scientific facts. No clear statement of these facts in any fullness exists in any language.

The method of this book, as we have already stated, has been to take the conclusions of one of the most experienced and observing painters, to compare these with the results reached by scientific experiment and by the use of definite facts and figures to explain them with all possible clearness. Careful study has been made of the relation of these facts discovered by scientific men to practical questions, and those conclusions borne out by experience have been stated.

In this chapter we shall attempt to sum up these practical conclusions and scientific results in still more simple language.

OILS.

The painter who knows nothing about oil knows nothing of his business. Linseed oil dries, and in drying undergoes great changes. It takes up part of the air, and loses something in the air, continuing to do this for at least three months. On the average linseed oil, paint or varnish is about three months in drying.

Linseed oil in passing through these changes protects itself more and more from the air, so that the changes go on more and more slowly, until finally they are stopped. The way the oil protects itself against the air is easily understood: as it grows harder the air is prevented by the hard surface from getting at the oil underneath this surface.

Linseed oil while fresh and soft, as on the first day of drying, changes very rapidly, raw oil and even varnish changes more rapidly, however, on the second day (or sometimes the third or fourth day) than upon the first. If these rapid changes are stopped by a current of cold air, trouble follows. If these rapid changes are stopped by a thin coat of moisture (water) gathering on the surface of the oil, less trouble follows, but still sufficient to cause what may be termed a mystery—that is, a change in the oil or varnish, the cause of which is not always evident. The most common cause of difficulty in drying paint or varnish, however, is a change of temperature, including a change in the amount of moisture (water) held by the air.

Linseed oil in drying changes from a liquid which easily separates into drops and is so light as to float upon water into a solid hard leather which holds itself together and to any substance on which it is put, and is heavier than water. This is a great change, and like all changes is produced by a force which has power to move particles from one place to another, or which, in other words, can *pull.*

Linseed oil in drying pulls itself together; it contracts. This is the principal reason why paint, and especially varnish, cracks. It is also partly the reason why varnish crawls, pitts, pinholes, gets "small-pox" and into all sorts of difficulties.

Linseed oil (especially varnish which is oil, turpentine and gums) is like other substances affected by cold: under a cold draft it contracts somewhat. Besides this contraction there are other results produced by cold in suddenly stopping the process of drying and not fully understood. In general, however, we may say that the contraction of oil in getting hard and the sudden contraction by becoming cold are the principal causes of the difficulties in varnish which we have mentioned—that is, these furnish the force which does the work. Whether the results (pitting, crawling, "small-pox," etc.) follow depends in some degree upon the condition of the surface on which the oil is drying. If this is slippery with not-dry oil, trouble follows when the pulling of drying begins.

This not-dry oil may belong to the partially dry oil of some coat underneath, or from tool, or other oil on the hands of carpenters or painters. Rubbing varnish often sweats—*i. e.*, the gloss of the varnish which has been rubbed off reappears because (possibly) some of the not-dry oil in the varnish has come to the surface.

Varnish and oil usually crack in a direction across the grain of the wood which they cover. The causes for this are (*a*) the fact that in the pull of drying the particles of oil find it easier to move with than across the grain of the wood, producing openings across the wood fibers ; (*b*) the pull of the varnish in its drying (during the first three months) is accommodated by the contraction of the wood in breadth. There is not much contraction of the wood in length, and therefore the contracted varnish becomes in this direction too short to cover the surface, or in other words, is severely pulled.

Oil dries more rapidly in the sunlight and under the influence of heat; but both heat and light cause a loss in the oil. One-fifth part of linseed oil is not drying oil, which keeps the dry hard oil softer than it would otherwise be. The effect of the sun is to drive off the not-drying oil by changing it into flying oil acids. Oil dried in the sunlight and exposed to the sun's direct rays will not last nearly so long as oil in the shade. Painters assert that oil dried in the coldest weather lasts the longest; it is difficult to see why this should be so, unless on account of the small loss of not-drying oil. When the oil is "dry" (that is, hard) the loss of not-drying oil goes on very slowly. A car or carriage freshly painted and exposed to the sun may soon perish; if allowed a few weeks to harden no such result follows exposure, the reason being that the hard surface protects the oil underneath.

It is probably true that oil lasts longer by being changed at once into a hard soap, and that some lead (not too much) is therefore an advantage in making up a drying mixture, or a paint of any kind not containing it.

It is recommended to wash freshly painted and varnished carriages in the hotter weather with cold water. This is undoubtedly a good practice, as it hardens the oil, preventing it from flowing, and the not-drying oil acids from flying away; but it is also doubtful whether the effect of the cold water lasts longer than a few hours.

One cause of the cracking of varnish is the pull of oil which had dried after the surface oil had hardened. Of course the surface oil is more exposed to the oxygen of the air and must dry faster; either for this reason or because of the pull caused by the later drying of the oil underneath the surface coat, there will be found on old varnish fine lines, which can best be seen on catching the reflected light from the surface with a good magnifying glass.

The more not-drying oil and the more drying oil not yet dry in an under coat, the greater power it has of cracking its overcoats. This relation of amounts of oil in coats placed one over another is one of the most important principles of painting.

The rule of painting is uniformity in all coats touching each other and uniformity in all coats overlying. Only the general principle can be stated; in following this out every painter necessarily uses his own judgment.

This principle, however, is not absolute, and grave mistakes are made in treating it as an invariable *rule*, the result being too great a load of oil upon the surface. It is impossible to foretell, except in a measure, which way or ways a thick layer or mass of drying oil will pull. All that can be done is to have a certain degree of "dryness" in every coat before laying another over it, and to make a certain uniformity between the two. It is necessary to prime with oil, otherwise we cannot protect the wood from water nor have any good foundation for our paint. To put as much oil in each coat as we use in the priming coat would be a sad mistake. A large part of the priming should sink into the wood; the less left upon the surface the fewer the chances of cracking.

Mistake is sometimes made in mixing the color coat with too much oil "to give uniformity." As we have said, uniformity is a principle (not a rule), arising out of the fact that oil in drying pulls itself together; but no man can foretell what will be the direction of pull in a thick mass of oil. These facts make it necessary that too heavy a coat or too great a number of oil coats should not be placed in one painting. Besides, too much oil in a color coat is probably a cause of the flaking of color from varnish, as well as a cause of cracking.

The pulling of thicker and partly dry boiled oil and varnish is stronger than that of thinner raw oil,and therefore it is dangerous to mix the two unless the mixture is thorough,and even then a little mass of raw oil may be on some part of the surface between masses of boiled oil, and bad results follow by inequality of pull. The varnish or boiled oil will dry hard while the raw oil is still soft and partly fluid, and various eccentricities may appear.

Finally, the cause of cracking is a change in the not-dry oil acids of inner or under coats. These acids may be drying acids, whose drying cracks the paint in the manner we have described. But they may also be not-drying acids, changed by the air into flying oil acids, and this is the greatest danger with which the painter has to contend. If his oil is adulterated trouble does not necessarily follow if he puts but one coat of paint on a surface. If, however, he puts on two coats with adulterated oil,the over-coat is in great danger of being broken up by the contraction of the under one, which is constantly losing substance—*i. e.*, its oil acids are constantly flying away under the effects of oxygen, light and heat.

See page 80, showing the drying of oils containing not-drying acids which are more easily changed by the air than are the not-drying oil acids of linseed oil. Linseed oil contains olein and palmitin; nut oil, especially, contains large quanties of laurine.

One of the best varnish makers in the country tells me that he once made some varnish of castor oil, but it cracked so badly he quickly gave up the experiment.

Gum Dammar (see close of chapter) contains much water. Like not-drying oil, it is constantly drying, and hence its danger to any coat of oil placed upon it.

DRIERS.

The relation of driers to oil is neither easy to comprehend nor to state. The following, however, seem to be the principal facts and legitimate inferences from facts :

1st. Driers act upon the oil like concentrated air, that is to say, air containing a large amount of oxygen.

Litharge contains 4 to 7 per cent. of oxygen.

Red lead contains over 9 per cent. of oxygen.

Black manganese contains 37 per cent. of oxygen.

Manganese monoxide contains 23 per cent. of oxygen.

Borate of manganese contains about the same.

Black manganese, however, although containing more oxygen than the other substances, is the weakest drier. Evidently merely the amount of oxygen contained in a substance is not the only fact necessary to know about a drier.

Borate of manganese is the most powerful of all driers, although manganese monoxide may be nearly as powerful.

Always should we look for the simplest causes ; and it is possible that the only difference between black manganese and the borate of manganese as driers is a difference of solubility in the oil. Borate of manganese more easily dissolves in hot oil.

There may, however, be another reason why borate of manganese is much the more powerful drier. It may give up its oxygen more easily to the oil. In studying rust, it may be remembered, it was found that ordinary rust differs from that kind of rust which best protects the iron from rusting by the ease in which it gives up its oxygen and the strong hold with which the protecting rust holds its oxygen. Like reasons can be found in the case of driers, and there is a gain in seeing clearly the principle that a drier can take up oxygen from the air and give it to the oil.

Very much has been said and written about the injury of a large use of driers; but no one seems to have had any definite ideas about the way in which this injury is effected. Crude ideas about the matter will not serve, nor can one rest satisfied with the nonsense written and spoken about this subject.

When a paint such as white lead or red lead is mixed with oil and works easily, we say it unites with the oil. This is largely a truth; and we may further say that pigments (paints) require less oil to bring them to such a paste as sold in the market in proportion as they unite with the oil. This uniting with the oil is soap-making.

Zinc white mixed with oil does not unite with it—that is, it does not at once form a soap. A little soda or potash added to oil does apparently have an effect upon it, for by making such a mixture we can produce a result impossible before, namely, get the oil to mix with water as a permanent mixture of fluids (emulsion).

However it may be at present, this is the method by which some of the widely advertised mixed paints were formerly made.

If too much of the soda or potash is put with oil, a soap results which will not be with water the same mixture (emulsion) as when a little of the alkali is used. We shall see in the next chapter what are the effects of soap-making, especially of lime and potash, upon the oil.

It should be said, however, that all mixed paints are not made with water ; but the warning is needed to buy no mixed paints of any house whose standing is not a guarantee of the purity of the article. It should not be forgotten that a long time and frequent trials are required to test a paint.

Red lead forms a soap with oil, and no paint is more lasting. White lead is a paint, and not a whitewash only, because about one-fourth of the lead unites with the oil to form a soap. This soap alone prevents the white lead from powdering ; but it has such a tendency to redden that white lead made by a process (one of Gruneburg's processes) producing a large quantity of this part of white lead which unites with the oil would turn yellow in an hour after mixture as a paint.

Red lead, litharge, and to some extent all kinds of manganese, including umber, form soap with oil. Red lead is a good drier, both because it contains oxygen and because it thus unites with the oil. There is no proof, however (on the contrary, there is proof for the opposite view), that soap-making by a small quantity of drier injures the lasting qualities of the oil.

It is probable, however, that driers injure the oil in the same way as the sun.

The sun's rays contain no oxygen, but they effect a union of the oxygen of the air with the oil, so that the life of a paint or varnish exposed to the sun is much shorter than the life of the same paint or varnish in the shade.

It is possible that manganese driers injure the oil by feeding it oxygen after it has already become sufficiently hard.

This statement is merely a forecast of probabilities—it must and should be tested by long experiment. It has not a few facts in its favor, but lacks the experimental basis. The attempt has been made to indicate a cause for the bad effect of driers, yet it must be said no one seems to have measured their effect upon durability of surface (not of color.) The use of japan containing shellac and substances affected by water may have led to the general opinion about driers. Also in varnish, already hardened by gums, the *loss of all elasticity by* change of the oil into hard soap has supported such an opinion. No subject needs more careful consideration by the painter than the effect of the driers used; we can only show him the elements involved, not decide his questions.

Both lead, and to a *less* extent manganese, injure the *color* of paint or varnish not exposed to the direct rays of the sun. As we shall see more clearly in the next chapter, the causes of durability of surface and durability of color are exactly opposed.

Boiled Oil.—Boiling oil is an operation which requires much attention, for carelessness may not only cause the loss of the entire quantity of oil operated with, but may occasion a very dangerous fire.

Gradually heated linseed oil gives off first water vapor, followed by heavy vapors with an unpleasant odor, products of the destructive distillation of the oil. This decomposition shows itself in another form by a phenomenon like boiling ; the oil bubbles and becomes darker. It is very important not to let the temperature rise beyond a certain point. Unfortunately no thermometer is used in this, the temperature being about 300° C., but only practical tests—such a one is, for example, the so-called feather test, which consists in dipping a chicken feather in the heated oil ; if the oil is hot enough the feather curls up with a crackling sound.

The evolution of acid vapors, which are particularly obnoxious to the membranes of the eyes and nose, has caused manufacturers to boil oil in the open air, an operation which is none too cheap, since a sudden shower, sending drops of rain in on the heated oil which vaporizes them at once, throws the oil around, endangering the workmen with serious burns. The heating of the oil should only be from the bottom, not allowing the fire to reach the sides; superheating is thus best avoided. Linseed oil is, like all other fatty oils, a bad conductor of heat. In order to prevent superheating, or even charring at the bottom, the oil should be carefully stirred up to keep the various parts of the oil at even temperature.

Lead Driers.—Mulder recommends red lead as giving the most elastic of all drying oils, and at the same time the hardest. It must not be forgotten, however, that these driers darken the oil and cause it in time to change color (yellow).

Any lead in oil, liquid driers, gold size or varnish, may have an injurious effect on all pigments containing an excess of sulphur, or sulphur gas may affect it. These are especially (genuine) vermilion, cadmium yellow, artificial ultramarine and many of the lakes. In all these sulphur is used, and in any of them sulphur may be in excess, left there purposely as an adulteration or otherwise.

These pigments are used in fine work, and the oil here recommended is a useful oil for common work. Even for fine work, however, a gold size or a liquid drier containing a small quantity of red lead has always been a favorite.

Mulder found that the average Dutch boiled oil contained two and a half per cent. of lead. He recommends the following:

Drying Oil.—Boil for two hours with 100 parts by weight of linseed oil 2 or 3 parts of litharge or (better) red lead. Oil boils at 600°.

If a clear oil is desired, filter and place in leaden vessels protected by glass from dirt, but exposed to the sun. It should not be forgotten that the process of oil-boiling is dangerous, and may cause destructive fires.

A drying oil made by adding one to three per cent. of fine litharge and one per cent. of sugar of lead, passing a stream of steam through the oil for one hour, which, however, needs a steam kettle for the purpose. We do not recommend such a proceeding if oil which will not change color is desired.

It is not necessary, however, to boil the oil to hasten its drying. As will be seen by table No. 11, oil merely heated to 212° with red lead for two hours is a quickly drying oil. Heating the oil alone does not cause it to dry more rapidly, unless it is thinly spread on a surface to which air has access. But with driers which give up oxygen to it, the oil is oxidized, the soft non-drying and free oil acids are made into soaps and the oil quickly hardened.

Condition of the Lead to be Used as Drier.—The litharge or red lead should be thoroughly dried and ground to a very fine powder. It is well to bake the lead for a couple of hours previous to using it, as any water remaining in it may cause explosions.

It must never be forgotten in handling or using powders of lead that they are poisonous, and careful cleanliness is always necessary.

Combining Driers.—It is better, in nearly all cases, to combine lead and manganese driers. The effect of previously rubbing up the drier with oil is also good.

Sugar of lead is an excellent drier, but has been accused of "eating" varnish and colors with which it has been ground. When sugar of lead (acetic acid lead) is added to oil, and the mixture heated, acetic acid is apparently unlinked from the lead. The acid is, therefore, free to injure the oil, but unless much drier is used the injury will not be great. Partly on account of the effect of the acid on the oil, sugar of lead unites with the oil to form an oxy-linseed-oil acid soap, which later may become red if out of the sun. It, therefore, like other lead driers, gives a hard, firm oil.

Borate of Manganese.—One part of this substance to 100 of oil, the oil warmed (212° to 360°) for one hour, gives a good drying oil ; it is better, however, to use as much as two parts of the manganese when an active oil is desired ; and the oil is improved if air be meanwhile blown through it. Prof. Church (chemist of the Royal Academy of Arts) recommends borate of zinc as the best drier for artists' use.

Drying Borate of Manganese.—(Two parts of, with 98 parts freshly-pressed linseed oil.) In diffused light.

	Linseed alone.	Linseed oil with 0.044 of a gramme of borate of manganese.
May 17	3.331 grammes.	2.760 grammes.
" 18	nothing.	0.015 "
" 19	"	0.204[†] "
" 20	"	nothing.
" 21	"	0.003 grammes.
" 28	0.025 grammes.	0.028 "
June 4	0.055 "	0.025 "
" 11	0.122 "	0.006 "
" 18	0.078 "	0.018 "
July 26	0.004[*] "	0.042 "
Gain	0.284 grammes.	0.341 grammes.
Heated to 176° lost	0.118 "	0.115 "
	0.166 grammes.	0.226 grammes.
Gross gain	8.5 per cent.	12.4 per cent.
Net gain, after heating and loss of flying oil acids	5.0 "	8.2 "

Sulphate of Manganese is a pink colored salt, useful, especially with zinc white, exposed to sulphur gases. It was the subject of a French patent, and the

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[*] Becoming yellow.

[†] Dry.

company holding the patent gives the following as an improved formula for its use:

Sulphate of manganese, 1 part.
Calcined sulphate of zinc, 1 part.
Acetate of manganese, 1 part.

These must be ground and sifted into a very fine powder. and then dusted over 97 parts of zinc white. An English method for its use is: 6 to 8 ounces of sulphate of manganese to 100 pounds of ground zinc white paint, the powder thoroughly mixed with a portion of the paint, and this portion thoroughly mixed with the whole. Unless care is taken in the mixing the work may be spotted.

Sulphate of Zinc, or white vitriol, was, perhaps, the first drier used in oil painting. It is not much used now.

Japans.—Japan is composed of either manganese or lead drier, or both in oil with shellac. About the usefulness of shellac we are very doubtful. It probably does nothing toward drying the oil, but simply produces a harder mass. A drier should leave no "tach," and this may be one of the advantages of a good japan. Japans, however, differ very much in the amount and kind of driers used in their manufacture.

Rules.

1st. Insist upon knowing what drier you are using by whatever name called. Avoid those containing much shellac.

2d. Avoid the use of verdigris, or much lead, or much manganese, where purity of *color* in the *dried* oil is desirable.

3d. Do not use more drier than necessary.

4th. Use both lead and manganese except perhaps for vermilion. One per cent. of lead and two per cent. of borate of manganese, or four per cent. of black manganese may be recommended.

Siccative.—This would be a good word to replace the word drier, as it is common to the English, French and German languages. Siccatives are driers for the use of artists. Too often they are made on the soup principle: the greater the variety of materials used the better the article. The true principle is the exactly opposing one—nothing should go into a drier or siccative but for a definite purpose. Lead, especially red lead, gives more soap and is less tachy, but *darkens the oil.* "Gums" also harden the oil; the siccative of Harlem is a favorite with artists, and is made with gums.

Muckley claims that gum mastic in the mediums used by English artists has been a great injury to their pictures, and recommends copal varnish as the best drier. The subject needs very long experience and great care to make advice of any value.

Some artists find immediate value in the use of siccative of Harlem, but the difficulty is to decide about *future* effects. The old artists no doubt used copal varnish as mediums, but did they mix it with *raw* oil?

The siccative of Harlem is probably made with copal and drying-oil, prepared as we have indicated. Bovrier recommends its use only in preparing the colors and on the surface, the "Siccatif de Courtray," which is simply drying-oil made with manganese and a little lead, being used for the ground.

THE THEORY OF BOILED OIL.

If oil be boiled gently for a very long time, it is finally changed into a very sticky mass—a sort of bird lime. If it is still longer boiled, it becomes more like rubber—indeed we can in this way change about 20 per cent. of the oil into an elastic oil rubber which has much resemblance to India rubber. The Dutch chemist Mulder has made a close study of this substance, and regards it as a most valuable one. Mulder regards linseed oil as belonging in certain aspects to both the fat acids and the resins or "gums." If it contains a little more hydrogen in its composition it is of the nature of the fat acids, if it has a little less it is of the nature of the resins. By heat we drive off the hydrogen as water and the glycerine ether, and get an elastic caoutchouc.

Another chemist, Dulk, has studied another substance used by the painter, namely Dammar,* and reached somewhat similar conclusions about it. He supposed that the Dammar "gum" was made from a substance which was not acid nor yet like the watery resin Dammar, which contains more water than any other "gum" used in varnish making. This substance he calls Dammaryl. Dammaryl taking up water (much water) was changed into an acid, which we find in Dammar "gum." All the "gum," however, is not composed of this acid, but of a watery substance, which Dulk supposes to be half way between the original Dammaryl and the Dammaryl acid, we have therefore:

1. Dammaryl.
2. " and water becoming Dammaryl "gum."
3. " and more water becoming Dammaryl acid.

Mulder reached like conclusions about linseed oil. Mulder supposes that part of the linseed oil is virtually a resin, and not exactly an oil acid. This resin is the elastic part, and to it the freshly dried oil owes its great rubber-like elasticity. He calls this resin the anhydide (*i. e.*, the water-free compound) of linseed-oil acid, because out of it the oil acid is made as the Dammaryl acid of Dammar gum is made, by taking up water to itself.

It is, however, not only the chemist who finds a difference between these two substances; the painter probably knows them well, because the oil-rubber (or anhydide) dries to oil leather, or, as Mulder says, "leather-like linoxine," for all the familiar names used in these articles have a scientific basis. The oil acid

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* The word Dammar means light.

dries, apparently, to fatty oil acid (or linoxic acid, as Mulder calls it) which is sticky and remains sticky. Mulder goes so far as to say that linseed oil acid does not dry at all—*i. e.*, it takes up oxygen, indeed, but does not for a long time change into oil leather (linoxine).

According to Mulder, we have then,

Linseed Oil
1. which is an anhydide,
by taking up water   *or oil rubber;*
becomes   by drying
2. *Linseed oil acid,*   it becomes
which by drying
becomes *fatty oil acid*   *oil leather*
(or *oxy linseed* which easily turns red)   3. (or linoxine)
which finally becomes
oil leather
(or linoxine),
a kind of resin.

FACTS ABOUT LINSEED OIL.

A. Chemical analysis of each product, which will not be given here because they would complicate rather than help the question in the mind of the reader. It must be sufficient that they give quite conclusive evidence to Mulder, who stands among the representative working chemists of Europe, *everywhere* trusted. We may, however, compare the results of his analysis of the fresh oil and of the partly dried oil:

Linseed oil is:

Not-drying oil	20 parts	Glycerine Ether 8 parts.
Drying oil	80 "	
Total	100 parts.	

The dried oil was found to contain:

Dried oil (leather)	91 parts.
Not-dry oil acids, etc.	20 "
Total	111 parts.

The oil had gained in drying 11 parts; but it had also lost the glycerine ether (8 parts): therefore the total gain was about 20 parts. On taking to pieces the dried oil leather, Mulder found that it had apparently gained in oxygen gas sufficient to increase the weight of the drying part of the oil by 21 per cent. One hundred pounds of oil, therefore, weighs 111 lbs. after it has dried; 21 pounds of this weight is oxygen gas taken up from the air.

No glycerine was discovered in the dried oil, but when burned it gave a slight order of burned glycerine.

B. The fact that linseed oil separated in any way but one into its two parts changes its nature. Linseed oil is

Glycerine ether Oil acid

If the glycerine ether is unlinked from the linseed-oil acid thus:

Glycerine ether Oil acid

then the oil acid no longer dries. It takes up oxygen, indeed, as much as 17 per cent. in a few days, but only becomes sticky, not hard and dry. After a long time, however, it dries in the same sense that good linseed oil dries.

A soap is—for example, a red lead soap is:

Glycerine ether
separated.

Red lead. Oil acid.

That is, simply because the oil acid has united to the red lead, the glycerine ether is left alone by itself.

Mulder found such an oil acid separated again from the lead, did not dry, but became a sticky acid.

C. If, however, linseed oil is heated to 176 degrees, some of the oil begins to break up thus:

and by letting the oil simmer in this way, we can change it into a greasy mass, which dries slowly enough.

D. If, however, instead of heating the oil in a kettle, it is spread on a surface in a thin layer and then heated, it will dry fifty times as fast as otherwise.

Moreover, in heating the oil in a kettle a great deal depends upon how much air it gets, and also how hot the fire is. Air, however, is the most important factor in making a good drying oil. The amount of heat is also important, but there are few facts about just the degree of heat, for it must be remembered we are speaking of an oil *without driers*. Without considering the matter of heat, however, we may say that when linseed oil breaks up (*i. e.*, the glycerine ether becomes unlinked, the oil acid free) the question whether it dries into a hard leather-like varnish, or merely changes into a sticky, an oil acid, depends upon the amount of air which can get at it. If it is spread in thin layers, and then heated and broken up, it will dry 50 times faster. Even in thin layers, however, we may heat the oil too much for the amount of air which can get at it. Finally, we can carbonize the oil by heat.

E. By long continued heat, however, we change the character of the oil heated in mass, so that it is soft and rubber like, and Mulder finds, as we have said, that one-fifth (1-5) of the oil can thus be changed into a substance which is so much like India rubber that he calls it oil-rubber. This substance he supposes to be much the same as the anhydide of linseed-oil acid, of which we have spoken, and out of which, by taking up water, oil acid is made, as Dammaryl acid is made from Dammaryl by the taking up of water to itself.

Mulder has studied the substance chemically, and in a small measure practically, and finds it to give the oil a rubber-like elasticity and that oil which contains it retains its elasticity a long while—he unfortunately did not experiment with it for more than a year.

Now it will be observed that all these are practical facts, and of importance in painting, if we consider it in any aspect. They have greater importance, indeed, in all fine painting than in any other branch, as we shall see.

This theory puts together all the painter's facts, and, like a man who has cautiously felt his way with many bumps around a strange room at night, the painter suddenly sees by its light just where he is *before* he rubs his shins against the chairs and tables.

THE NEED OF ELASTICITY IN PAINT AND VARNISH.

We have seen that linseed oil has three grades of elasticity :

1st. The long boiled oil (without driers), which contains a true elasticity or rubber resembling India rubber.

2d. The raw oil freshly dried, which also contains an elastic rubber-like substance but possibly of a somewhat different nature.

3d. The hard dry oil leather, which has a leather-like elasticity of its own, coming partly from the not-drying oil acids it contains.

The long boiled oil (without driers) has the greatest elasticity but is too soft a substance to use as paint ; therefore driers are added to the oil to harden it, but these destroy more or less of the elasticity by changing the oil-rubber into hard soap.

Lincrusta-Walton, which is one of the best and most useful materials for wall-decoration, is made of linseed oil containing a large amount of true oil-rubber mixed with sawdust. As a certain hardness and yet great elasticity are needed, a little of the oil is made into soap.

It has been shown in the chapter on the cracking of varnish that cracking results not so much from want of elasticity as from different rates of drying in different coats. Wood has usually little destructive effect upon the oil. A moderate amount of elasticity in paint and varnish will serve nearly as well as a great deal if the wood is on all sides thoroughly protected from water, and if the drying coat (*i. e.*, all the combined oil coats of one painting) is not too thick.

Elasticity comes from not yet dry oil-rubber, which will certainly dry by and by, and exert greater force, producing large cracks in the varnish the more elasticity there has been in the oil. English varnish is dangerous because it is elastic ; its cracking is incurable in large and deep clefts. There is no doubt that American varnish makers are correct in producing a varnish for general use which shall dry quickly, because it contains a moderate amount of oil which, when dry (over dry), cracks in fine checks often only a coat or two in depth.

Rubbing varnish, however, contains too little oil and too much soap for safety. If used at all, it is well to mix it with finishing varnish which contains more oil and less drier.

Varnish consists of some oil leather, some oil-rubber, besides linseed oil unchanged, or as a loose compound of linseed-oil acid and glycerine ether. We must not forget, as we have pointed out on page 70, that the elements of a chemical compound may be closely bound together or loosely combined, or finally unlinked, and that in each of these conditions the qualities of the substance may be different.

Thus we have, as regards the oil, three or four different substances in varnish, and by adding driers we have another, namely a hard soap.

In this boiled oil "gums" are dissolved, and, apparently, the union of the oil and the gums is only physical, not chemical ; the particles are mixed, not linked. The lustre of the varnish is due largely to these gums ; but the particles of gum must be connected by particles of oil; if the oil sinks away (as all the not dry part may do) into the wood, the gums are left as particles, not united with a perfect surface. Whatever destroys the close union and mixture of particles (whether it changes the gums as does the dampness of a damp place where the varnish may be stored, or whether it changes the oil, as does ammonia), breaks up the smoothness and perfectness of the surface.

The gums being hard, harden the mixture, the oil gives the mixture its elasticity; but if it be largely soap and have little of the oil-rubber in it, the mixture is brittle. If there is much of free oil acid (as produced possibly by too much heat and too little oxygen) in the varnish it will dry slowly, and in time change so much after the over-coat (if there is one) is hard that the layer will crack open. If there is much of the oil-rubber in the varnish it is the best possible as to durability and elasticity, if the gums are hard and durable also. The gums are a difficult subject ; they are changed by water and by oxygen. The more water they contain, apparently, the more they are liable to change—the older and harder the gum, the less water, apparently. But we are dealing with uncertainties. All we know positively is that the hard gums little affected by heat are the lasting ones. The kauri gum is the most colorless, the copal and amber the hardest but darker, so that a clear varnish will not easily be made from either of them. The fresher the kauri and the more turpentine in it the less lasting.

As to the effects of cold, this is largely probably in a slight destruction of the mixture of the gum and the oil, as the effect is often curable by heat. The effect of water and dampness is upon the gum. The effect of gases is upon the drier. The effect of ammonia is upon the oil. The effect of heat is nearly always good if the surface underneath is not porous; it is bad if it is so, for the not-dry oil goes in and leaves the gums with some dried oil on the surface.

To sum up the matter, elasticity in a coat means a coat which has great destructive power; it will thereby last longer, but produce in time incurable cracks which cannot be painted upon.

Finally we must look to the feeding of oxygen to the already dry oil for the destructive effect of driers upon paint and varnish. Driers harden the oil by making it into soap; this also is destructive if the oil is made too hard, *i. e.*, if the oil or varnish contain too much soap.

Not more than two or three per cent. of lead or manganese drier should be boiled or warmed with the oil.

CHAPTER II.

THE ECCENTRICITIES OF OIL AND VARNISH.

The use of drying oils has its mysteries as well as all other affairs of practical life, but the painter should be thoroughly impressed with the fact that observation, time and knowledge will unravel them all. The main thing is to look for general causes in particular ways (experiments); such general causes as, for instance, the influence of the atmosphere, mixtures of various unlike substances with each other and want of honesty and fair dealing on the part of those who supply materials and those who use them. Too much stress must not be laid upon this latter course, especially not unless positive proof can be brought.

Eccentricities due to Atmospheric Causes.—Chill-cracking, that is, very fine cracks extending in all directions as though the varnish had begun to crystallize. Cure, *heat.*

Pin-holes.—Little holes as though made by a pin point; the cause, apparently, a chill when the varnish is fairly under way of hardening. No cure but heat and time.

Curdling.—Much like the curdling of milk. Cause, a chill to varnish to which coach japan has been added.

Crawling.—Due to a cold room, as it seldom, if ever, occurs in summer. The immediate cause is some oily matter on the surface. Rub surface with a damp shammy.

Clouding, *Whitening.*—A varnished surface toward a window may appear brilliant; the other side, away from the light, cloudy and dull. The cause is moisture in the air, which may be due to the weather or to a damp floor. Example: Two finished cars, rain for two days; varnish lost all lustre. The third day those sides toward the sun renewed their lustre, other sides remaining dull and cloudy. Cure, heat or light.

Alcohol varnishes are specially prone to this difficulty, and should only be applied in a room heated to 70°.

Turning Blue.—A film of blue, in which one can write a name with the finger, covers the surface. Cause, coal-gas. Cure, more air and *sunlight.* Moisture will temporarily give a blue color to varnish.

Eccentricities Due to Unclean Surfaces.—All these are due to oil on the surface, either non-drying oil from the varnish or paint of surface, or from oil on the hand (as tool-oil), or oil from the oily skin of the hand. Carpenters, before the car is primed, painters and varnish-rubbers may be at fault. An oily shammy is another cause of difficulty. Especially should the painter never forget that the human hand is always oily (from the oil-glands in the skin), more so when it perspires.

Crawling.—(As above).

Small Pox.—Greasy surface-varnish, on which the varnish crawls into blotches.

Peeling in a mysterious and single spot (round), due to failure of the priming to enter the wood, because of oil (generally tool-oil) previously taken up by the wood.

Rusting.—An appearance of having been under a stream of water from rusting iron; appears in spots. This may be due to a surface (of a car, for instance) which at some time within several months has been washed with lye water, to ashes blown against a car or a carriage and wet by rain-water, or to ammonia-water or gas.

Blistering.—Oil on the surface by the means as above stated. Too much japan in colors, the shellac in the japan the cause of the blistering. Wood not dry. Water left in a porous rough-stuff. Benzine in varnish or colors. Too great heat, as the concentration of sun heat in one spot by a "bull's-eye" in a glass of the shop window. Always the result of vapor or gas under the influence of heat.

Eccentricities Due to the Painter.—Sagging Down.—The varnish appears in festoons or curtains. This is due to the use of too heavy a load of varnish on the brush and want of *courage* to spread it vigorously before it sets. Also to carelessness. In paint, little streams appear, or brush marks, due to using too much paint and to mixing it too thick or too thin with turpentine.

Brushes.—Bits of pumice stone or dirt in varnish brushes will give a deal of trouble. But the danger is *in using English varnish with brushes which have not been kept in varnish.*

Varnish.—Using the last one-eighth of the can of varnish will give trouble. It should be kept for rough work.

Eccentricities Due to the Manufacture and Quality of Varnish.—These are very difficult to come at. *Sweating* may be the fault of the varnish, because *possibly* oils other than linseed may have been used, or because the insufficiently melted gum was not thoroughly incorporated with the oil.

Sweating, however, may be caused by the failure of the painter to allow varnish time before being rubbed. It may also be due to dampness in the atmosphere. Also to old varnish which has become fatty—and in both cases the cause is the same—presence of free oil acids. A London painter claims that varnish which will bloom one day will do so the next. This is doubtful, but it is well to test in fair weather, to discover by way of proof.

"Deadening," or "Sinking in," Change of Color, etc. —Kauri gum, and probably manilla, of which by far the greater part of varnish is made, quickly loses its lustre, although not necessarily its wearing power. This should not, however, occur for several months If the dullness come immediately, it is probably not the fault of the varnish ; or if it is, that fact can be positively proved by experiment with a remnant of the same lot, if any remain.

The method of melting or making a solution of the gum (all gums) for the varnish may affect its lustre.

Prof. H. Schwarz, a German chemist, regards the green tinge in varnish as due to the action of the oxidized glycerine ether (acroleine) of the oil affecting the copper of the vessel in which the varnish is made.

The principal causes of immediate deadening and loss of lustre in good varnish, however, are to be looked for in two directions : (1) In the condition of the atmosphere. Moisture tends to separate the fine particles of gum from the dried oil. Gases dull the surface. (2) In the condition of the varnish. Test it on various surfaces. Experiment with the varnish over a similar coat, if porous, putting the sample under strong heat for several hours, to see if the oil is driven in and taken up by the coats beneath, and lustre lost in this way. Finally, as a cure, try the effects of heat and sunlight.

Perishing.—The varnish may lose lustre without perishing. Immediate or rapid perishing may be caused (1) by putting the surface under a hot summer sun *too soon.* Allow it plenty of air, but no excessive sun in summer for ten days. (2) The effects of ammonia vapor or water. (3) Varnish made of the cheaper gums. (4) The use of too much manganese as drier in varnish or paint exposed to the sun's direct rays.

Mysterious Cases of Cracking.—As for instance two cars painted and varnished at the same time and in the same way. One cracks badly before it leaves the shop, the other remains perfect. Exclude first all causes of chilling from openings in the floor and other sources of draught. Then look out for unfairness on the part of some one—putting oil in some coat of the varnish to make it work easier, etc.

No one has a right to make such a charge, however, except on a basis of facts. It is cowardly to take advantage of one's position to make unproved charges.

Flaking of Varnish from Color.—See Carriage Painting.

CHAPTER III.

THE EXAMINATION OF LINSEED OIL AND OF TURPENTINE.

The oil should be clear and pure, not thick and cloudy. It should be bright, but may not be perfectly bright, because there is still unsettled mucilage in it. It should be sweet ; nevertheless there are those who prefer an oil of a peculiar, bitter quality, known only by experience, but like the bitter of cotton-seed oil. This may be because such a taste indicates an old and therefore well settled oil. Litmus paper may be used to test the fact whether sulphuric acid has been used to clear the oil. If any quantity of the acid remains in the oil, the blue litmus paper will become red.

The unaided senses can say only, this oil is not a thick, rancid oil. To test its quality further, we must *dry* a sample.

Tests for Adulterations.—The most dangerous adulterations of linseed oil are : (1) fish oil, (2) cotton-seed oil, (3) rosin oil, (4) mineral oil. Crude menhaden oil is at this time nearly one-half the price of linseed oil. It is an oil which when cold has little odor and much the color of a dark linseed. The unchanged oil can, however, easily be detected by thoroughly heating a sample, when a strong fishy odor will be apparent. Whether this odor can be destroyed we cannot say, but it is probable that it can be so weakened and disguised that a linseed oil adulterated with such prepared fish oil would not at once be detected, even on gentle heating.

Cotton-seed oil cannot be detected by odor, and has so many characteristics of linseed that any test is difficult. The pure linseed oil is to be preferred to cotton-seed, but a linseed slightly adulterated with cotton-seed would not be a very serious injury in rougher work. Its greatest disadvantages would be slowness, its tendency to crack coats placed above it, and an increased tendency to crack in severe weather. In the under-coats of a finer painting such oil would be very dangerous.

The writer has sought long and carefully, and with the aid of others, for some *easy* and reliable test for linseed oil adapted to painters' use, but it must be confessed that the result has not been successful. It is not difficult to give tests for unmixed oils, but these tests are of next to no use practically, because it is only a mixed oil, an adroitly mixed oil, that will be offered to the buyer as a pure article. It is of the first importance, therefore, to purchase oil of the seed crushers, or of thoroughly trustworthy agents. Cheap oil should be avoided, and especially all " improved " oils of every kind, and by whomever advertised.

Some of the following tests have a little value :

The sun is the best chemist to render oil clear and white. Even if an oil be dark, sunlight soon clears it. If an oil be very dark, it is wise to try the bleaching power of the sun upon it—putting the oil in a long, thin vial, with the stopper partly removed, in order to allow the access of air. If it continue dark, especially if it have a reddish cast, shake up a sample in a test-tube with aqua ammonia (the stronger ammonia diluted with two or three times as much of water). Ammonia gives with linseed oil a bright, but not transparent yellow. Crude cotton-seed oil with ammonia gives an opaque brown, and a mixture with linseed oil a brownish and, especially, a dull opaque yellow. Menhaden oil with ammonia becomes white. Refined cotton-seed oil becomes a light, transparent yellow.

It will be seen, therefore, that the test has value only in exceptional cases. Equal quantities of fluid ammonia and oil can be used ; the stronger ammonia gives deeper colors, and may be used in less quantity.

In testing oils use two test tubes of small size, such as may be purchased at any good drug store for five cents per tube. Fill the tubes only one-third full of oil (one tube should contain oil known to be pure), add the ammonia and shake the mixture. Hold both tubes (1) against the clear sunlight, (2) before a piece of white paper, (3) before a piece of black or yellow paper, in order to get the full effect of contrast.

Mineral Oil.—Adulteration with mineral oil can be detected by fluorescent qualities (metallic play of colors)* which it imparts to all vegetable oils, and by the strongly marked aromatic, burning flavor it communicates to mixtures containing it. The first-mentioned property is brought out by smearing a metallic surface, such as a tin plate, and then viewing it at different angles in the open air in sunlight. So characteristic is this that most mechanics who use oil can detect mineral oil at once, even when present in small quantity.

Rosin Oil (*see Turpentine*).—A simple test for rosin oil is to shake up a small quantity (teaspoonful) of

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* This can be disguised by treatment, and is not true of all mineral oils.

oil with five times as much strong alcohol; pour off the alcohol and add to it a clear solution of sugar of lead. A cloudy precipitate shows the presence of rosin.

Rosin oil may also be detected by taste, but not by odor.

Rosin oil or rosin in linseed oil gives the oil a "tach," and it is said never to harden completely.

It is especially to be looked for in boiled oil, but most difficult to detect.

Albumen (*plant flesh*).—If albumen is present in the oil it will give a clabber-like precipitate when boiled with one part muriatic acid and four parts water.

Cotton-Seed Oil.—The best test is by cold. Place a sample of pure oil and of the suspected oil in a refrigerator; if much adulterated with cotton-seed oil, the impure sample will become thicker than the pure.

Crude cotton-seed oil produces a brown deposit on a piece of bright copper foil (to be had of dealers in chemicals) if left in the oil for three or four days in a warm place. Linseed oil becomes green under the same circumstances, and leaves a greenish deposit on the copper foil. A mixture of the two oils would not give results of value to any one who had not carefully tested individual cases, but we would advise use of this simple test.

Fish Oil.—Place the oil in a test tube, some pure oil in another tube, and heat both tubes gently in warm water. If the suspected oil gives no fishy odor, it is probably not adulterated with fish oil. Do not be too certain of ability to detect fish oil; snuff at both tubes, for the smell of acrolein (*i. e.*, oxidized glycerile) is not unlike the fishy odor, which indeed partly depends upon it. The writer has been given instances of fishy odors in white-lead cans of first-class makers, and in the water from newly painted roofs, which may have been due to acrolein and flying oil acids, although they may have arisen from the fact that the linseed oil used had been adulterated with fish oil.

Specific Gravity.—Tests for linseed oil by specific gravity have little value. The specific gravities of various oils, as given by Mr. C. M. Stillwell, of New York, are as follows :

Poppy oil	0.9245
Raw linseed oil	0.9299
Boiled linseed oil	0.9411
Crude cotton-seed oil	0.9224
Refined yellow "	0.9230
White winter "	0.9288
Menhaden oil (dark)	0.9292
" " (light)	0.9325
Tanner's oil (cod)	0.9205
Porgy oil	0.9332
Rosin oil (third run)	0.9887

Temperature, 59 Fahr.; co-efficient of expansion, 0.00035 for degree.

General Test for Adulterations.—In order for a general test for adulterations of a suspected specimen of oil, it is necessary to have a sample known to be pure for comparison.

About half an ounce of the suspected oil is placed in a clean, dry test-tube, five inches long and half an inch wide (such a tube is easily obtained of either wholesale or retail drug houses). The same quantity of oil, known to be pure, is placed in a similar tube, and both are allowed to stand in water of ordinary temperature of your room, for ten minutes. The tube of suspected oil is left standing in the water, and the pure oil from the other tube poured into it. When the two oils come into contact, layers will be formed, in case the suspected oil is adulterated in any way. If the oil is pure, no layers will be formed, and it will be impossible to see where the oils meet.

These layers resemble the currents which flow upward and downward through water when it is heated from below—the so-called "convection" currents. This test needs practice, and will give results only in the hands of a practiced observer. The same may be said of tests by "cohesion" figures—if indeed these have any value in testing mixed oils.

Another Method.—A useful method (used for testing the suitability of linseed oil for the manufacture of linoleum) is as follows:

To 100 parts of oil add ½ of 1 per cent. by weight of litharge and ½ of 1 per cent. of red lead. Heat the whole in a large basin or saucepan until an immersed thermometer indicates 480° to 500°, taking care that the oil gets no hotter then 500°. Air should cautiously be blown into the hot oil by means of a glass tube attached to a foot-bellows. Small samples of oil are taken out and cooled from time to time on an iron plate. As soon as they appear stringy when cool, the oil is allowed to become cold, being constantly stirred during cooling. If the oil be solid when cold, the sample is of good quality. Bad oil remains sticky and half fluid.

TURPENTINE.

Turpentine is an oil which is valuable in painting, because it liquifies paints, oils and "gums." Linseed oil is valuable because it remains; turpentine because it does not. Its nature as an oil is therefore quite different from linseed oil.

Its use in nature, as in painting, is to dissolve and make fluid. Our hardest varnish gums were once dissolved in a turpentine, which would indeed be valuable to us could we discover it. Common turpentine is made by "boxing" or cutting deep holes in the pine tree, dipping out into barrels the crude turpentine which collects in these, and distilling it with water. Crude turpentine boils at 316°, and it is kept just below this heat, but water boiling at 212° carries the turpentine with it up through the still pipe and over into a vessel ready to receive it. What is left of the crude turpentine is rosin, which contains all the oxygen, turpentine oil being composed (like benzine) of hydrogen and carbon. When used as paint it should "dry" in 24 hours, and leaves a varnish of rosin which consists of turpentine and oxygen. By such drying in the long past were all our varnish gums formed.

Professor Church, of the Royal Academy, who has apparently studied the matter, says there are two kinds of turpentine, one boiling at 320° and the other at 350°. The boiling point of average turpentine is given as 320°. It is seldom, he adds, that oil of turpentine is free from acids; in nice work and when delicate pigments are used it may be worth while to test with litmus paper, which will turn red if the turpentine contain much acid.

Here we may call attention to the effects of turpentine in producing fatty oil—*i. e.*, in changing the character of the drying oil acid to a somewhat sticky and not-drying acid—and in affecting certain pigments when these occur together, as white lead and madder, or cochineal and madder. Artists using small quantities of color notice their changes more than painters, and Muckley has pointed out that flake white and rose madder mixed with turpentine or with oil and turpentine may change color in twelve hours ; and like results may also follow in cochineal and madder lakes when mixed together with turpentine. The turpentine in these cases may not be pure, but it is not impossible that even old turpentine containing large amounts of peroxide of hydrogen may produce like results.

As to the effect of the turpentine on drying there is uncertainty. Chevreul reached the conclusion that it hastened drying, Mulder that it very much retarded drying. Another chemist has shown that peroxide of hydrogen (which is made by the action of air on turpentine) changes drying oil into not-drying oil (oxy-linseed-oil acid ?). Turpentine thins oil but may change it to not-drying oil, if it contains much peroxide of hydrogen—at least this is not improbable.

Turpentine that is acid contains pyroligneous acid (fired-wood acid), which will settle from it in time, and for this reason old turpentine is better than new.

Several new methods of making turpentine are being introduced, by which more pyroligneous acid is obtained. Both methods extract the turpentine from the wood—even from old, dead wood. From a cord of wood one process extracted :

Turpentine - - -	24½	gallons.
Pyroligneous acid - - -	88	"
Pine tar, - - -	120	"
Charcoal, - - - -	56	bushels.

There is much dead pine wood in the turpentine regions—especially in North Carolina—which can be utilized in this way ; but it must be proved that the turpentine is as good an article, lest danger to paint arise from its introduction. I know nothing against it.

Benzine is not a proper substitute for turpentine. It is said to cause the blistering of paint if used in its preparation, the blister being of a peculiar character.

Rosin is turpentine plus oxygen, and perhaps somewhat else. It is useful for many things, but not to be put in boiled oil, nor to use as a "gum" in paint or in varnish. The painter is cheated by its use in both of these ways. It is brittle, and easily crumbles. It is, however, valuable in making paste and (with shellac, sulphur, etc.) hard cements.

Rosin Oil.—By distilling common rosin, either mixed with steam or without, products are obtained, of which the chief are: a watery liquid containing acetic acid, a light and flying oil or spirit, and a heavy oil known in commerce as rosin oil. Superior rosin oil is made by treating it with slacked lime, and then distilling. Rosin oil is much used with lubricating oils for machinery and wagon wheels. It has a specific gravity of 0.96 to 0.99 (rosin a density of 1.07), and if added to linseed oils, as it often is, especially to boiled oil, makes their specific gravity greater—the specific gravity of linseed oil not being higher than 0.937—boiled oil, 0.941. Specific gravity tests, however, are not of much account, because there are lighter oils to put with the heavier rosin oil. Rosin oil is free from smell, even when heated, but has a peculiar taste which is not disguised by the linseed oil. Put a drop of oil on the back of the tongue with a glass rod and taste carefully, avoiding too hasty a decision as to what you have got. Rosin oil is remarkable for the nauseous after-taste of rosin produced by it.

Adulterations.—Light rosin oil, crude, undistilled turpentine and rosin itself are sometimes used to adulterate turpentine. "The admixture may be recognized by the alteration in the specific gravity of the oil and by the reaction produced on adding 8 drops of stronger ammonia to 90 cubic centimetres of the turpentine." The following are the results. (They are not very distinctive, but may be of some use, especially the specific gravity test):

	Specific gravity.	Reaction with ammonia.
Pure oil of turpentine recently distilled..........	0.8678	No effect. The mixture separates rapidly.
Old pure oil of turpentine....	0.8693	Solidifies in a few seconds, forming a white crystalline mass of the consistency of butter.
Turpentine with 10 per cent. of rosin spirit.......	0.8784	An emulsion, which rapidly becomes clear; the ammonia which separates has a pale yellow color.
Turpentine oil with 10 per cent. undistilled turpentine......................	0.8784	An emulsion, which becomes clear on standing, gives a semi-transparent gelatinous sediment of bluish color, the liquid above being colorless.
Oil of turpentine, with 10 per cent of rosin..........	0.8831	Each drop of ammonia appears to solidify as it falls into the oil. On agitation, the whole solidifies into a consistent, transparent mass.

CHAPTER IV.

THE COLOR OF LINSEED OIL AND CHANGES IN VARNISH.

There are so many varieties of change in the color of painted and varnished surfaces that we must distinguish these from each other, at least in a general way, before making an intelligent study of this subject.

Of course, the cause of some of these changes is a matter of opinion, but there is scientific opinion for some of those which will be most quickly disputed.

Changes in Color of Paint.

Change due to	*Cause.*	*Tendency.*	*Result.*
Oil..................	No sunlight.	Reddish.	Yellow.
Resins, etc...........	In wood.	Yellowish.	Yellow brown.
*Ammonia gas.......	From manure.	"	Brown yellow.
Lead pigments.......	Sulphur gas.	Black.	Black gray.
Lead driers..........	" "	"	Gray.
Manganese driers....	Oxygen.	Brown.	Brownish yellow.
Verdigris............	"	Dark.	Blackening.
Mixtures of pigments.	Optical relations.		Muddy colors.
Sinking in of oil.....	Heat, etc.		Loss of brilliancy.
Fading of colors,.....	Light and air.		Less distinctive — whiter or darker

Changes in Color of Varnish.

Change due to	*Cause.*	*Result.*
Oil.....................	Too much heat in boiling.	Dark.
Gums.....................	Too dark.	"
†Copper varnish kettles...	Not clean.	Green.

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*Ammonia and sulphur gases are found together. The direct effect of ammonia upon oil is to yellow; of the sulphur gas on the lead pigment or drier, blackening.

† The difficulty is with the gum kettle or the still. The cure is silver plating, or (a cheaper one) a coat of true amber varnish. This difficulty (green varnish) must not be confused with yellow varnish, which over a black color appears green.

Change due to	*Cause.*	*Result.*
‡Dampness	Change in gums.	Dull.
"	" "	White.
Lead driers	Sulphur gas.	Dark.
Manganese	Oxygen.	Brownish yellow.
Ammonia gas		" white.
Oil	Want of light; heat.	Yellow.
Yellow oil over black		Olive green.
Coal gas		Blue.
§Sinking in of oil	Want of proper foundation.	Loss of brilliancy.

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‡ The gums are separated to some extent from the oil; it is a mechanical and not a chemical change.

§ Common kauri gum quickly loses its lustre without other changes, but the best quality holds its lustre well.

Changes in pigments will be treated of in another place.

The Color of the Fresh Oil.—Linseed oil should always be bright, of a more or less yellowish green color. It is not so bright nor so light of color when fresh, because, apparently, of some of the coloring matter of the seed plant which has been pressed out with it. How much of the plant substance, the plant flesh, is in the seed is a very open question, which no chemist would wish to decide hastily. Mulder asserts, however, that there is very little, and that of no consequence, except as to color. Oil to be boiled especially needs to be freed from this turbid muddiness, or it will, under heat, become very dark. As stated on page 75 there is reason to believe that imperfect oil mixed with the coloring matter of the seed is the cause of this change of color.

To get rid of the coloring matter of the seed in the oil (or the colored oily matter) and of all plant flesh, time only is necessary. Oils are much too soon used; in as many weeks as months should be allowed, *i. e.*, in three weeks instead of three to six months.

The process is, however, hastened by sunlight, and if the oil be put into leaden vessels exposed to the sun, a clear and more quickly drying oil is produced. The same effect is produced much more rapidly in glass bottles, likewise exposed, and not tightly corked. The effect is hastened if certain substances (see close of article), and among them old turpentine, be added to the oil. Turpentine takes up oxygen from the air and produces peroxide of hydrogen, which aids in bleaching the oil.

Another method is simply to heat the oil to 170°. If air be blown through it at the same time, its drying properties will be improved, and a clearer oil produced. A more troublesome method is the filtering the oil through animal charcoal. This process makes the oil water clear, but still gives no advantage in drying, as will be seen by the following table. I have not been able to find any facts proving that a dark oil dried more slowly.

Water-clear Oil Filtered Through Animal Charcoal.

			Grammes oil.
April	4		1.992
"	5	gain	0.003
"	7	"	0.004
"	11	"	0.044
"	16	"	0.150
"	22	"	0.810
"	26	"	0.004
May	4	loss	0.002
"	14	gain	0.002
"	28	"	0.004
June	18	"	0.002
July	26	lost ....(BECOMING YELLOW)**	0.002

The oil does not begin to dry vigorously until the seventh day, and it becomes yellow exposed to clear sunlight, although when placed in the sun it was water-bright.

Effect of Caustic Potash and other Alkalies.—How these substances act in purifying the oil is not certain; but it is probable that they form more or less soap with the imperfect not-drying oil with which is mixed the coloring matter of the seed (see Drying Oils). If this be the case, the not-drying oil soap settles from the body of the oil, leaving it brighter and clearer.

But we are not sure that there is not also soap-making with the drying part of the oil. Says the Chemist Mulder: "I doubt the usefulness of this partial soap-making by an alkali, partly because litharge gives a better drying oil and partly because the alkali mixed with the oil gives an oxy-linseed-oil-acid-soap which becomes red in the air." It is well, therefore, to test all prepared oils by drying on glass and then placing them in perfect darkness for a number of days. Those which become more yellow may have been cleared by the use of caustic potash or some such substance ; care is needed to get the same thickness of oil on each glass.*

This, however, is only a comparative test for oils and varnishes, because both will become yellow in darkness with time. There is, nevertheless, a great difference in oils, as shown by comparison of paints made with zinc white and with white lead. Zinc white contains at least 14 parts of oil; lead contains only nine or ten parts, and yet :

"In the year 1852 Mr. Holman Hunt painted a picture entirely in zinc white, which stood perfectly so far as purity was concerned, but it became much more transparent as it dried further in the course of time, so that the outline showed through in many places."

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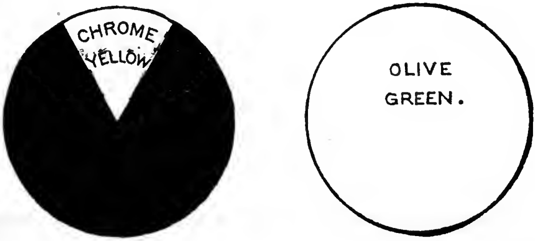
* Potash, lime and carbonate of baryta soaps most quickly redden in the air. Verdigris, lead and manganese soaps also redden, but less rapidly and in somewhat the order given.

"The changes in white lead and linseed oil are rapid and inevitable. A foul, tawny yellow quickly overspreads the work utterly destructive of delicacy and freshness * * * * they have always been fatal to these essentials of a landscape" (Mr. Twopenny in the *Quarterly Review*).

White lead has two color changes; it blackens on exposure to sulphur gases, and it yellows in the shade. This last change is due entirely to the oil. To the same cause is due the change of color on a carriage body which is a little old, or has been kept from the light. A chrome yellow light toned down becomes an olive green, as may be discovered by such a disk as the following: The easiest method of mixing colored lights is to place the colors on a disk and twirl the disk.



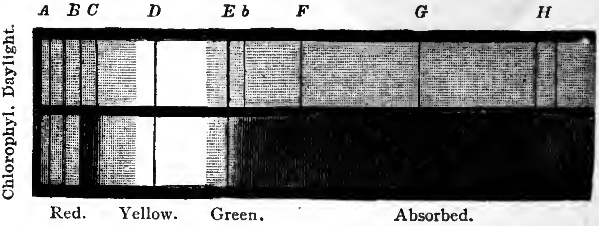
FROM MODERN CHROMATICS.
(*D. Appleton & Co.*)

The difficulty with such a carriage color is not at all in the black pigment, but in the yellowed varnish over it, especially the rubbing varnish, which is probably full of soap. And to some degree, perhaps, in the oil with which the black is mixed. The only possible cure, aside from removal of the varnish, or recovering with new color, is sunlight.

Some carriage painters use black, others asphaltum varnish in place of rubbing varnish; this may be a partial preventive, but so long as there remains oil-varnish above to yellow and below a black color, there will result a greenish tint.

Sunlight changes red oil to colorlessness, for the yellow oil is apparently on the way to a red color. Those who doubt this fact should observe the increasingly reddish-cream changes in the color of white-lead of badly lighted rooms.

The changes in color in oils may perhaps be made clear by observing the spectrum (*i. e.*, the separated colors) of the green coloring matter of plants, which, as we have already shown, probably exists in the pressed oil. Linseed oil is green or greenish yellow when fresh; when heated it becomes red. Green and red, therefore, stand at each end of a scale of change, in which yellow occupies the centre. As the oil of white lead begins to change it becomes yellow, but with increasing age it takes on an orange cast, *i. e.*, it contains more red and less greenish color, for red and green unite to make yellow. Above are the separated colors (spectra) of leaf-green and of pure white sunlight (daylight).



The green leaf substance contains (see lighter surfaces in the cut) much red, very much yellow and green, the bluish green, blue and violet being swallowed up. Oil is colorless, green, yellow, or red. On our walls as it loses its colorless or greenish cast it turns yellow, because there is more red in the color, red and green producing yellow. Although we cannot make a pure and brilliant yellow by mixing together a green and a red light, yet we can produce a yellow, and there is reason to believe that all yellows are a mixture of red and green rays (see Rood's Chromatics, page 116). If we heat this dried oil it becomes quite red, that is to say, the green disappears altogether. In the sunlight, however, the red fades away and the oil becomes colorless, but it may in doing so first turn to a yellowish and then to a greenish cast. I am merely supposing the case in order to show the connection between red linseed oil acid and the yellow color of white paint.

Thus we find our way from red oil to green carriages—did the oil change completely enough, we should probably find a brownish red carriage instead of a green one.

It is more than probable that all boiled oils, all oils containing much soap, especially potash or lime soap, change color in this way more rapidly than raw oil, and of course the more oil the more the color shows itself.

CONCLUSIONS.

Changes Produced in Oil by Heat.—Dried oil heated to 176° loses weight and becomes reddish. Linseed oil acid, oxy-linseed oil acid and dried oil-leather all become red when heated. In the sun, however, they all become colorless again. The sun is, therefore, the most active of all purifiers of oil, and it acts with greater advantage when the oil or varnish is spread. One may safely use, in all work exposed to direct sunlight, a dark oil or varnish which will bleach in the sun in a small vial uncorked. Long-continued heat of the sun, however, probably reddens (yellows) the oil.

There are, possibly, three sets of color items : (*a*) The turbidness of imperfect oil ; (*b*) the reddening of oxy-oil acid ; (*c*) the darkening by an excess of flying acids remaining in the oil.

The change in color seems, in considerable measure, due to the oxy-linseed-oil acid, which may become blood red. All substances, but especially potash and lime, which change the oil into soaps, produce in time red oxy-linseed-oil acid. Strong soaps have more tendency to redden than weak soap when simply exposed to the air. Therefore all excess of driers or soap-making substances is to be avoided. Krems white contains less soap-making substance than ordinary white lead ; and, says Mulder, "for 26 years I have observed that it does not so much change to yellow as does common white lead." "A neutral carbonate which I have prepared, mixed with poppy oil, remained unchangeable in darkness."—*Bulletin des Sciences*, 1839.

It is plain why lead changes color more than zinc—it contains more soap. White lead by a process which gave an excess of water lead was found to yellow in an hour after mixture with the oil. Also it is plain that any lime as an adulteration to lead or zinc will soon greatly discolor the paint.

Again, it is plain that boiled oil, which contains much oxy-linseed-oil acid and much soap, will darken sooner and more completely than raw oil. To avoid change of color, we must avoid that which most quickly dries and hardens the paint—soap. Even manganese driers with zinc white will yellow the paint.

It is possible, however, for linseed-oil acid or the hard dried oil-leather to redden somewhat by heat, or in the shade.

All the discolorations of the oil, oil acids and the dried oil are more or less completely removed by the sun's direct rays. The heat of the sun long continued may, however, yellow the oil.

Slowly dried oil containing a large amount of flying oil acids darkens more than oil dried quickly in the sun.

It is important, therefore, for all these reasons, to use as little oil as possible in interior house painting with white colors.

It is equally important that the layer of paint should not be thick, so that the oil may get all possible light, and the flying oil acid escape ; and it would be well if the paint could be dried by a strong but not excessive heat—not above 80°.

Poppy-seed oil, which more quickly loses its stickiness, although it does not dry so hard, and walnut oil : the drying part of these oils is the same substance (linolein) found in linseed oil ; but they do not, perhaps, develop so much oxy-linseed-oil acid, which is very sticky and becomes blood red. Poppy-seed oil retains its colorlessness longer than linseed oil.

The Raw Oil.—We may now return to the question of purifying the color of the raw oil. Sulphuric acid is used: does it injure the oil?

Mulder has made a special study of sulphuric acid in its relations to oil. He treated some linseed oil with strong sulphuric acid and spread it upon a surface. It dried as follows:

DRYING LINSEED OIL.

April	8.		0.430	of a	gramme.
"	11.	Gain	0.001	"	"
"	16.	"	0.020	"	"
"	22.	"	0.052	"	"
"	26.	"	0.003	"	"
"	30.	"	0.002	"	"
May	14.	Loss	0.002	"	"
"	21.	"	0.006	"	"
"	28.	"	0.004	"	"
July	26.	Gain	0.002	"	"
Dec.	19.	Loss	0.005	"	"
Net gain.			14.6	per cent.	
Loss by heating			3.0	"	
			11.6	per cent.	

Oil usually gains not more than ten per cent. in weight, and keeps, after heating, a gain of 7 or 8 per cent. Oil treated with sulphuric acid gained nearly 15 per cent., and kept after treating nearly 12 per cent. It will be seen, therefore, that sulphuric acid does not greatly injure the drying oil, but that it changes the soft, not drying-oil acids so that they take up oxygen, but do not fly away. Sulphuric acid is not a great injury to oil, and it does not (according to Mulder's experiments) cause the oil to change color after it is dry. In fact, it seems to affect only the not-drying oil acids (palmitin and olein), and not to change the drying acids nor to unlink much of them.

The oil, however, dries more slowly; in the experiment it first begins to dry after eight days.

The great objection to sulphuric acid in purifying oil is the danger that some of the acid left in the oil may affect white lead or delicate colors of the fine pigment. The oil may be tested by litmus paper (to be had of any druggist), which is changed from blue to red by an acid.

Mulder recommends for clearing turbid oil mixing it with its volume of warm water containing common salt.

Oils are probably injured in color by alkalies and driers rather than by the acids used to clear them.

The following is the advice of a practical varnish maker:

It is known that the fat oils, both drying and non-drying, are obtained by pressing out the plant fibres in which they occur.

The refining is usually performed in the following manner: The crude oil is treated with sulphuric acid, which destroys the foreign materials, but leaves the oil unaltered but black in color from the decomposed material. After the oil has cleared again it is decanted from the settlings and washed with water to free it from the acid. According as the refining is more or less carefully performed, the oil contains smaller or greater amounts of foreign materials. These foreign materials hinder the oil from drying (?), and it is advisable to treat the oil with an aqueous solution of such substances as have the property of forming insoluble substances with the above bodies (plant mucilage and plant albumen).

Bleaching the Oil with Copperas (ferrous sulphate) Solution.—Make a solution of 220 lbs. of copperas in 35 gallons of rain water. Place 22 lbs. of oil in a glass flask holding 3½ gallons. Add from four-fifths of a gallon to one gallon of the solution. Place the flask or flasks in a room where they will be exposed to the direct rays of the sun, and shake them at least once a day. If the sunlight is strong the oil will be bleached in three weeks; if less strong, it may require six weeks. The clear oil is carefully decanted from the solution and kept in glass bottles.

The same solution may be several times used; as it becomes weak add more copperas.

Bleaching the Oil by Sulphuric Acid is accomplished in a similar manner to that explained in the second paragraph above—"general refining."

Bleaching with Sulphate of Lead.—Sulphate of lead is a white, insoluble powder, which can be easily made by bringing sulphuric acid together with sugar of lead solution. In order to bleach linseed oil with this preparation, 2 per cent. of the weight of the oil is taken of the lead sulphate and rubbed together with a very small amount of oil on the rubbing stone, until an intimate mixture is obtained, and this is then diluted with more oil to a milk, which is then added to the rest of the oil, which must be in this case also in light glass flasks.

The turbid liquid clears slowly, and after a few weeks the oil is found quite clear and bleached; the foreign materials which were contained in the oil now lie as a fairly solid skin upon the settlings of lead sulphate, which can be used many times for the same purpose.

Other Changes in Varnish and Colors.—Aside from the change in the color of the oil there is also another change in the color of the varnish. Glass is transparent because it is a continuous and unbroken sheet. If we reduce it to powder, it is no longer colorless, but white. Varnish is composed of fine particles of "gum" dissolved in turpentine and oil. If the "gum" or, rather, resin, has not been perfectly dissolved in the oil it will at once turn milky when the turpentine is added to it in making the varnish. Again, if one varnishes with a volatile varnish (turpentine, alcohol or other varnish) in a damp air the dry varnish will be dead and cloudy.

The same change takes place, but more slowly, in oil varnishes, and is due to the evaporation of water on their surface. Prof. Max Pettenkofer has produced this condition in two days (frequently wetting the varnish with a brush and allowing the water to evaporate), in a mastic varnish which had remained clear for five (5) years. But how do we know that it is not the oil which is affected?

(1.) Because it takes place most rapidly in varnishes which contain no oil. (2.) It is curable by such substances as have no effect on oil but which dissolve the "gum."

If a picture varnish in this condition be placed over a cloth wet with alcohol it takes up the alcohol vapor even to the extent of 60 to 70 per cent. of its own weight; and when this vapor is evaporated the white cloudy varnish is again hard, transparent, perfect as before. Experiment with alcohol vapor and dried oil shows that the oil takes up no alcohol vapor, and that varnish takes up the vapor in proportion as it contains "gum."

We are, therefore, warranted in believing that so trustworthy an investigator as Prof. Pettenkofer is correct when he says that this appearance of varnish (the clouding and whitening) is due to the separation of particles of gum, which particles are softened and dissolved by alcohol vapor, and the little spaces which existed between the oil and the gum filled up.

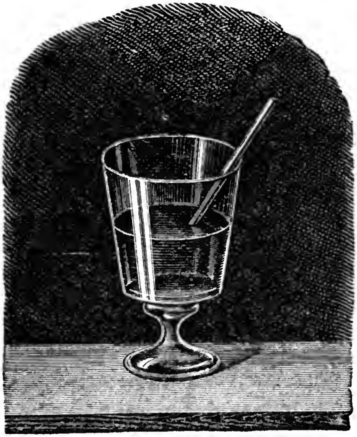
By this simple method (the use of alcohol vapor) pictures which were entirely invisible have been brought back to life ; and colors which were supposed to have faded or changed proved to be still in their prime, suffering only from the separation of the particles of "gum" in the varnish which had been put on to protect them. In the gallery at Munich 52 per cent. of the pictures in the northerly exposed room, 16 per cent. in the southerly room, and 10 per cent. in the large and better protected room between the two were affected with this varnish disease.

The Ultramarine Disease.—One picture Pettenkofer speaks of in which the green of the landscape seemed mixed with yellow and blue, as though the color had badly changed ; but treatment of the surface with alcohol vapor "restored" the color, if we may call that restored which was never injured. Ultramarine was found especially prone to this difficulty of change of color, spots of ultramarine seeming to have changed so much as to produce a type of difficulty known among artists as the ultramarine disease, and this Pettenkofer attributes to the clay-like character of the pigment, which gives it a special liking for water.

In treating this ultramarine disease the surface was also rubbed with copaiba balsam, a Central American resin, which modifies light very nearly as does linseed oil, so that the minute cracks drinking it in and by it filled disappeared after the same manner as the glass beads in the following experiment:

This effect of the balsam (which is also used by Pettenkofer for the restoration of pictures) is another proof of the fact that the gum had separated into fine powder, represented by the beads in the following experiment.

"If we fill the lower part of a small glass tube (a test tube) with coarsely powdered glass, the powder will appear white, and it will be impossible to see through it, but as soon as we pour water into the tube the powder will become translucent to a certain degree. By substituting the turpentine for the water, the degree of translucency is considerably increased. Furthermore, if we add a small quantity of sulphuret of carbon to the turpentine, we shall obtain a liquid which reflects (bends) the light about as powerfully



as glass, and if we now pour some of this liquid upon the powder, the latter will disappear almost entirely to the eye, and we shall be able to look through the glass freely as if it contained only the clear fluid without the least particle of powder. If we immerse a glass rod in such a liquid (instead of which we may also employ a mixture of olive oil and oil of cassia) it will appear as if the rod reached only to the surface of the liquid. Within the liquid the presence of the rod cannot be detected ; it is perfectly transparent as shown by the illustration. Instead of the powdered glass, small beads of transparent, colorless glass may be used. They will become invisible as soon as the liquid dislodges the air between them.

"It is shown by these experiments that the presence of one transparent body within another is only betrayed to the eye when the two differ in their power of refracting light. If this is not the case, the light passes through the mixture without obstruction."*

It is plain, therefore, that the cause of changes by apparent fading, yellowing or becoming green of pigments under varnish must be looked for at first as a change in the varnish unless the same change takes place when no oil or varnish is present.

In a Nut-Shell.—Oil in paint or varnish tends to become yellow (red) if it has in any way been separated before drying from the glycerine ether, consequently boiled oil, including all varnishes, and all oil and varnish containing soap, is apt to change color when out of the sunlight. This change turns our carriages green, and the less light the whole or any portion gets (as inside the door-frame) the

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* Von Bezold's "Theory of Color."

yellower the green. It changes the white lead of house interiors to yellowish streaked (sour) cream, unless zinc white has been used as at least an over-coat. It produces various sorts of odd combinations on all oil-colored surfaces. Finally, with the exception of the reddish woods, it "sicklies o'er" all our natural wood surfaces (varnished).

For this disease there is but one cure—the sun. It is true, however, that the evil may be partly alleviated by the use of poppy oil, which has less tendency to yellow, and possibly it may be in some measure prevented by the use of East India flaxseed, whose oil is said to have less tendency to change than ours. Many white-lead makers claim to use this oil,* some do use it, but a clear demonstration of the amount of advantage over our native oil has never been made. It is possible that by careful selection of seed an improved quality of domestic seed might be produced.

The second cause we have described. It acts more promptly in the case of all the softer gums and resins. A blow will change a lustrous resin varnish to such a white powder. The cheaper grades of kauri soon begin the change under the influence of damp air, and even the slightest changes affect the colors underneath.

Finally the earthy pigments (ultramarine, umber, etc.), can become separated from the oil by water. This is probably part of the reason for the destruction of darker colors in pictures (see page 105).

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* Because they claim it works better with the lead, or that their customers prefer it.

CHAPTER V.

The Carriage Varnish Shop.

No one can write upon this subject with the purpose of fully covering the ground without being endebted to that excellent journal *The Hub;* and we at once express our obligations to it for many suggestions, points and hints.

It is not our intention, however, to follow its lead further than necessary.

The Requirements of a Varnish Shop as to Situation.—The two necessities of a varnish shop are plenty of warm air (without draughts) and freedom from dust.

Strange as may appear this last requirement is more easily satisfied in the city than in the country. In cities tall buildings abound; in the country districts, the varnish shop will probably be situated on the second floor of a loose, open, wooden shop near the road, whose dust, swept up by the strong winds of summer and autumn, enters cracks and crevices, and is spread over the freshly varnished surfaces. As any one may easily observe, dust is not carried in quantity to any great height, although particles of dust and shreds of clothing and even bits of coal will be found in the air about the tops of high buildings. Paved streets of the city, a situation above the dust line, and finally better floors, make the city varnish shop much more favorable for good work.

Nothing is more destructive to a good job and the patience of a good workman than dust; and in the country it is well to take precautions which are not taken even in the best city shops.

Location.—For reasons which we will enter into before the close of this article, it is well to have two sides of the shop exposed to the open air, in order to better ventilation. " The floor should be of hard wood, thoroughly seasoned boards nicely matched together, and laid double ; " all seams and imperfect places puttied with hard putty, and the floor thoroughly painted. (Egbert.) In exposed situations the bottom of the doors should be below the surface of the floor, as can be easily effected when the latter is double. The door should if possible open into another room, better if upon a warm room. In country shops where this is not possible it would perhaps be a saving to put up a close weather-door, leaving some space between this and the inner door. The inner doors should slide, the outer doors may be hung on hinges ; both should contain a small door. In city shops opening into the rubbing or other rooms, free from dust, sliding doors level with the floor are sufficient. In Brewster's (Broadway) shop, which is one of the best appointed in the country, a drying room with sliding doors opens from the varnishing room.

In country shops the great difficulty is with the flooring, the character of the work done in the room below and the exposure of the large doors.

The Walls.—The walls and ceiling should if possible be hard finished, and are better for thorough painting, except where the ventilation is small, when painting is not to be recommended. Where hard-finished walls are not possible, a tight finish of matched boards is next in order, but no moldings or projections, and as far as possible no shelves, should be left to catch dust. Base-boards should be flush with the surface of the wall. A good color for the room is a very light tint of blue.

Size of the Room.—There are two considerations to be taken into account. The room must be large enough to work in without discomfort and without danger of rubbing against new work in stooping, rising and passing to and fro.

The second consideration is equally important, viz., that the size of the room shall be sufficient for proper ventilation. About one-third the air coming into a room enters through the solid walls. This fact is of more consequence in the varnish room, because here all cracks, crevices and openings afford entrance for dust; and, of course, the greater the wall surface the more air entering the room. Air, however, will not move through walls nor move at all, without a force. The force which ventilates the room is the difference between the heat of the air in it and of the air on the other side of the walls; consequently the colder the weather outside, and the hotter the room inside, the greater the amount of air passing in and out. If the outer side of the walls open upon other rooms the air must enter the varnish room from these; and, as the varnish room needs all the pure air it can get, it is better, as we have said, to have at least two sides with walls exposed to the open air. Wind striking against such walls is also a ventilating force. Brick is porous and a good material for walls if not filled with water, when its pores are stopped and the air prevented from passing through. It is well, therefore, to paint the outside surface of bricks facing stormy points; and it it well in building to furr off the inside walls, not placing the plaster too near the brick. This prevents the inner wall from sucking up moisture from the wet bricks, and makes an inside drying surface for the bricks.

Windows.—As has been shown, sunlight is the most powerful of all driers; next to plenty of fresh air the most economical article which can be brought into the shop is diffused sunlight. Two things should be noted here: First, that the direct rays of the sun may injure and especially blister the paint; it is well to have a blue shade to cover windows into which the sun shines. Especially dangerous are "bull's-eyes" in the glass of such windows, as these concentrate the light and heat and cause mysterious blisters.

Second, air is rapidly cooled by contact with cold glass; if the windows are large there is danger, in colder weather, in exposing a freshly varnished surface too near the glass.

Loose sashes exposed to windy points should be fitted with weather-strips; and care should be taken to stop all cracks in the floor or crevices about the doors through which a draught can reach the varnish.

Heating.—There are two considerations to be taken into account:

First, To avoid all dust and gas from the fire.

Second, To secure a uniform temperature in all parts of the room without exposing any varnished surface to great heat. There are four methods of heating:

1st. By wood, which, however, involves (in most localities) too much expense, and the danger of dust blown into the room by draughts down the chimney.

2d. By gas stoves—expensive and not abundant in heat, but giving no dust.

3d. By steam. This is the best method. The steam-pipes should not be placed in one part of the room as is common in steam-heating, but distributed to all sides. It is well, if possible, to have a set of "flying" pipes, which can be used to hasten any job if the shop is a large one, as is often the case with car-shops; the pipes can be placed directly under the car.

Care must be taken that the pipes are kept perfectly steam tight at all joints (for reasons given below), especially in smaller rooms.

4th. The common method of heating, however, will be by coal stoves. The first requisite is a tight, self-feeding and base-burning stove; although of course any good stove can be used.

It has been recommended to set up the stove in an adjoining room with about one-third its bulk projecting into the varnish room; this requires a special arrangement of walls, but is an excellent plan. If this method be used, however, a piece of Russia sheet-iron should be bent around the stove and made dust-proof at all joints.

Not always will such precautions be taken. It is a more practical matter to consider the prevention of the radiated heat and the ventilation of the room.

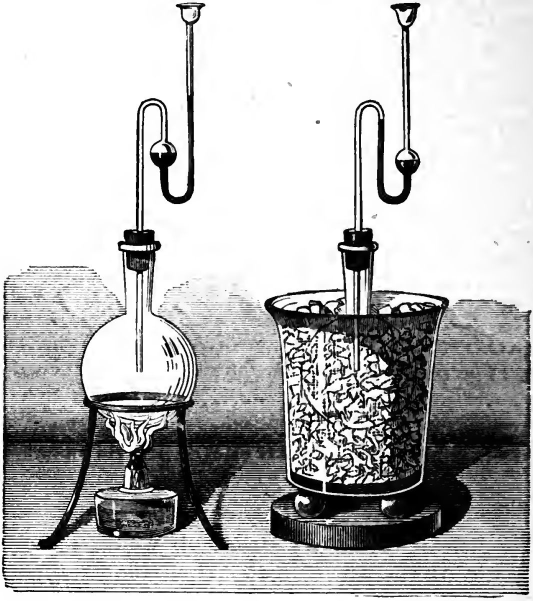
Ventilation.—Now as to ventilation. Enough has been said through the columns of the different journals devoted to the interests of the craft, to convince the most skeptical that fresh air is necessary for the varnish room. To get rid of the foul air, and fill the room with pure, fresh air free from dust, are the objects sought to be attained. The room can be rid of the foul air by a flue in the centre of the ceiling and extending upward above the roof. The top of the flue should terminate in a pipe with a revolving cover or cap, similar to those used on chimneys, to keep the wind from making the flue "draw the wrong way." The bottom should be square at the ceiling, and closed by a door fitting the inside closely and hung upon the centre. This can be opened or closed, partially or wholly, by simply pushing up either side with a rod kept for the purpose. An 18-inch flue should be large enough for any ordinary-sized room. To admit the fresh air, every alternate window should have its main sash 18 or 20 in. short of the uniform height of the windows; into the space thus left at the top another sash should be fitted, hung upon hinges at the top and arranged to swing inward and upward; this should be weighted so as to stay at an angle when opened, thus letting in just the quantity of air desired, and should, when closed, form a window uniform with the rest. Outside this swinging sash a frame covered with the fibrous, dust-proof screen should be closely fitted, the bottom of the frame overlapping the outside of the top of lower sash, and stoppered with rubber at the edges. Thus you can admit fresh air in large or small quantities and at the same time feel that dust and flies are effectually barred out.—*Egbert, in The Hub.*

I would ventilate the room, according to its size, with one or more 15-in. ventilators through the ceiling and roof, and with cupola and weather blinds; and would have a trap and iron rod in the ventilator to regulate it.

I would have a dark room in connection with the varnish room, in order to run my work into it in summer, to avoid flies, etc.—*McGill, in The Hub.*

The most perfect method of ventilation would be the inclosure of the stove in zinc, and the construction of an air-box from the roof, or from some upper window at a point free from dust, which should feed the stove with air. Were it possible to have a flue from over the hearth to a chimney, or to the roof, which could be opened when the ashes were removed, we should have a very nice arrangement. In any case, the room needs an inlet and outlet for air; and the former should open within an inclosure about the stove; and the latter should have an adjustable stop.

In large shops these arrangements are not required, and are a positive disadvantage, since heat ascends to the ceiling. Such shops should be heated by steam and cannot be properly heated by stoves. Where stoves are used some sides of the car or carriage will dry more rapidly than others; and more or less



*The effect of ice and of heat upon air in a flask. The contractions and expansions are shown by the position of liquid in the neck of the tube.**

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* The difference in the air is in its energy when hot or cold, but this is best expressed by its bulk.

trouble from chill-cracking will probably occur. Movable screens are a positive necessity. At the best, much time will be lost in such shops in the colder weather for want of heat to dry the paint and varnish.

Thermometer and Barometer.—Every shop should be furnished with *several* thermometers hung at various points. The proper temperature for the best drying is 70 to 90 degrees.

Here we must speak of a matter generally misunderstood. Air is like a sponge; the tighter it is compressed the less water it can hold. Cold compresses the air and, therefore, in winter it contains much less moisture than in summer. As air becomes warmer it is less compressed and will hold more water.

The illustration represents the effect of heat and cold upon air. It will be readily seen that as the air becomes warmer it has more room for water between its particles.

A cubic centimetre of atmospheric air contains in a state of saturation at various temperatures the following quantities by weight of vapor:

Temperature. Centigrade degrees.	Grammes of vapor in air.
0	5.66
1	6.00
2	6.42
3	6.84
4	7.32
5	7.77
6	8.25
7	8.79
8	9.30
9	9.86

Temperature. Centigrade degrees.	Grammes of vapor in air.
10	10.57
15	14.17
20	18.17
25	24.61
30	31.93

It is evident from the above facts that the heated air—*i. e.*, cold air raised to a higher temperature—will be thirsty for water. If the varnish room floor is wet or if there is a sink or pump or other exposed wet surface, the air will soon become moist. Moist air has two effects upon varnish and one upon paint.

1st. Moist air deposits a coating of water upon paint or varnish and thus protects it from the oxygen of the air and prevents further drying.

2d. As we have already seen in the chapter on Changes in Oil, varnish is subject to change by separation of the gums from the oil, and that this effect is produced by the evaporation of moisture. The moisture apparently unites with the gum and precipitates it from the oil in the same manner as occurs when water is added to a solution of gum in alcohol. It is probable that water is much more active upon gums in the undried than in the dried oil; and that a single coat of moisture can produce an effect of this kind in drying varnish.

Here we may speak of a matter which is of great importance to the painter. Some varnishes are more sensitive than others both to cold and to moisture, and these often have the best working qualities and give the best lustre. Part of this sensitiveness may arise from the amount of oil in the varnish. Part may come from the kind of gum. Still another part may come from the amount of heat used when the oil and gum were united.* Looking at the matter practically, however, the main point is that the painter should know his varnish and its degree of sensitiveness to atmospheric changes.

On damp days, not cold, it is evident the painter can do nothing to prevent the air from being moist. He can, however, keep up a strong heat and see to it that the floor of the varnish room and all other surfaces are unusually dry.

There is a whitening of varnish on damp days which is merely the result of condensation of moisture upon it, or in other words a mere deposit of dew. But there is also, as we have shown, a permanent change (dullness, loss of lustre, whitening) caused by such a deposit of moisture.

Moist Heat and the Lungs.—The painter's health as affected by the atmosphere of the varnish room is also an important matter and little understood.

1st. We feel moist heat much more quickly and acutely than dry heat. In England, the thermometer in the average house will show in winter 62° as the temperature of the air ; in this country from 70 to 80°. Our climate is not only colder but dryer, and air at 80° does not produce so much warmth as would the moister air of England at the same temperature. We keep our houses, however, too hot because the dry cold air of some of our winter days accustoms us to a high temperature. One can enter a dry hot oven which, if the air were moist, would be scalding hot.

A certain degree of moisture in air is required for

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* Also the drier used may have an effect.

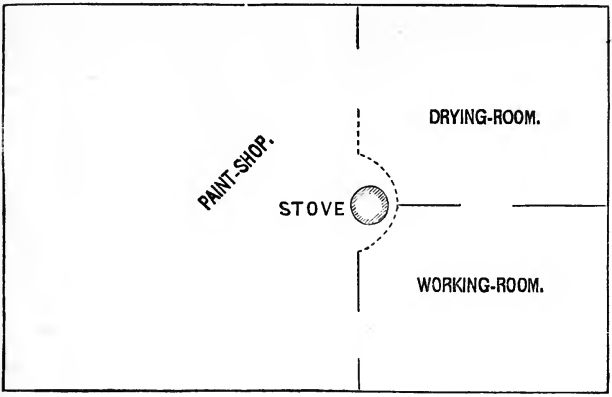
healthfulness; but a moist air inside a house on a day when one must pass from it to a cold dry air outside is not desirable.

The human lungs are constantly giving out moisture, and this moisture in the air cells at the lower part of the air tubes is mixed with refuse matter from the blood. Every one who has breathed dry hot air knowns that it drys the mouth and throat. Moist air which is not so moist as it can be also takes up some moisture from the mouth, throat and air tubes; and it is a curious fact that whatever the temperature or the amount of moisture of air when it enters the mouth, it leaves the mouth as breathed air at a standard temperature and full of moisture.

For this reason cold air (which must be gradually warmed in passing through the air-tubes, and as it is warmed, its capacity for moisture is increased) takes up its moisture from the deeper portions of the lungs where impurities thrown from the blood are mixed with water.

Partly for this reason, one feels invigorated by breathing cold air. To go, however, from a room which has left the moisture to accumulate in the lungs, into a dry, cold atmosphere, is to endanger the breathing organs. Colds, bronchitis and pneumonia may be occasioned in this way. The atmosphere of a varnish room should, therefore, both for healthfulness and for other purposes, be not too moist, nor too dry. So far as healthfulness is concerned a condition of moisture which is not unpleasant to one coming into the room from the dry, cold, outside air is not hurtful. On the other hand, a dryness in the air which does not dry the mouth and the throat is sufficient.

It should not be forgotten that the shop air, moist from the breath of the men and from other sources, becomes a special source of danger at night if the fires are allowed to get low, or the heat is shut off.



F. B. GARDNER'S PLAN FOR A VARNISH AND PAINT SHOP.

(*From The Hub.*)

The floor should be water-proof, and it is well to give it an incline toward a shallow gutter through the centre all around the edge of the room.

Furniture of Shop.—Brushes (in kind and number to suit the workmen's taste); sponges, shammy, cups, and cup-stands, screens in abundance (which can be made by tacking or pasting paper upon suitable frames for deck panels) body-rests on castors and in sufficient numbers. The painter can fill out, vary and extend this list at pleasure; little is necessary, but a saving in tools is usually a *constant loss in time.* The absolute necessities of a shop are only light, protection from dust and cold and one or two men with good judgment. The best shop, the fullest knowledge and the longest experience without these go for little.

PAINTING A CARRIAGE.

For wise reasons we shall in place of definite directions such as are given for painting a car give only general principles and their modifications. No one can paint a carriage by a book; but in a book one may find a helpful expression of prime facts and fundamental principles, which even experienced men often lack in the furnishing of their minds.

Priming.—It is unnecessary to repeat what has already been said on this subject. One must prime with oil, drying oil is the best, but any thickness of whatever kind of oil used left upon the surface endangers the future of the work. Do not, therefore, prime too heavily; nor believe so much in improvements as in good judgment in using *linseed* oil as a primer.

Rough-Stuff and Filling.—These are solely for the purpose of giving a good surface. That filling of whatever nature which will give a permanently smooth surface without danger by cracking is the best. This principle is fundamental and condemns the piling on of oil coats for the mere purpose of getting smoothness.

SEVERAL VIEWS.

Now make putty or stopping thus: Mix dry white lead with equal parts of elastic varnish and gold size into putty; add one-fourth of its bulk of keg-lead, tint with lamp-black, and knead thoroughly. After the body has been puttied two or three days, proceed to fill as follows: Take of French umber, Reno's filling and white-lead, equal parts; grind stiff in turpentine; add to this two parts of elastic varnish and one part of gold size. Give three coats of this, then add a little lamp-black for a guide coat, and give a fourth coat. See that each coat is thoroughly hard ; then it is fit to grind down. When ground down, give a coat of flat lead-color with a camel's-hair brush, and when this is dry examine thoroughly and scumble or glaze any defective places ; and when they are hard smooth them off with a small piece of pumice stone, and prepare the whole surface with No. ½ sandpaper ; the foundation is then complete.—*Oatmeal Pasha in The Hub.*

Now you will perceive that four coats of lead form quite a mass. Then followed four coats of yellow ochre filling, the most of which, however, was rubbed off in pumicing, leaving the surface of ochre filling no thicker than a sheet of letter paper. Now was it this layer of filling or the lead coats that absorbed the oil ? In my opinion the trouble commenced with the first coat of lead priming, and that the wood having absorbed the oil, japan and turpentine, left on the surface a layer of white lead in a powdered state. The turpentine which entered into the composition of this priming reduced the oil so much that it had little or no effect in satisfying the fibres of the wood, and the powdery lead left on the surface then became the medium of passing the oil of all succeeding coats to the wood, and therefore the final sinking in of the varnish. When an absorption of this kind takes place, it always shows any imperfection in the lead, such as brush marks. For instance, when the lead is brushed up and down, and the brush is run crosswise at the top and bottom of the panel, this change of brushing shows very distinctly through the thin dim lustre of the varnish. Now if the last coat of lead had been faced smoothly, these brush marks would not be seen ; but to do this would involve a great amount of labor, and even after such labor absorption would take place. White lead, no matter how mixed, does not answer the purpose of a rough-stuff. The slate, or what is called "English filling," comes nearest to perfection. It makes a close, smooth and elastic surface, rubs well, and seems an almost indestructible pigment. Compare it, if you will, with white lead, and, for example, take a body that has four coats of lead on, having oil as a base, and a body that has been rough-stuffed with English filling. At the end of four years you can remove the whole surface of lead by the use of sandpaper, but if you try to remove the English filling by the same means you will fail, for it resists the action of the sandpaper as a piece of glass would.—*Capt. OConnell.*

"Patent filling" is prepared for us by mixing it with white lead, gold-size, varnish and turps, in the following proportions: Two parts of "patent filling," one of tub lead, two of turpentine, one of Japan gold-size, and half of bottoms of wearing varnish, and laid on in the same way as heavy varnish. "Grafton filling" should be mixed as follows: To four parts of the powdered paint, add one part of tub lead, and mix with a sufficient quantity of good wearing varnish bottoms to bind it; or part gold-size and part varnish could be used instead of the latter; then reduce by the addition of turps to a proper working consistency. The "filling up" composition may be rendered harder in drying by increasing the quantity of varnish and decreasing the quantity of turpentine; or the opposite result may be obtained by decreasing the proportion of varnish and increasing that of the turpentine; and although it is possible to add varnish to the extent of rendering the "filling" so hard that it would be impossible to rub it to a smooth surface, yet great care should be taken against having it too soft or thin, for the harder the "filling" is (within reason) the better surface does it present for painting.

It is a great and common mistake to apply heavy coats of filling to a body. It is far better to give light coats, with an additional one. If "filling" be used too thick, and laid on with a coarse, stiff brush, the heavy brush marks in the first coat will give the surface a ribbed appearance, which will be repeated in each of the succeeding coats, by the hairs of the brush dividing upon the ridges formed in the first coat: so that the ridges, having more "filling" upon them, will not dry so hard as in the grooves where the "filling" is thinner; and hence when the body is rubbed down to a surface, and painted and varnished, the places where the ridges have been, being much softer, will continue to show through. This can easily be avoided if, when "filling up," the painter would lay off his coat crosswise or at right angles to the direction of the preceding one, which will obtain a surface of a uniform depth. It should be remembered that the "filling up" being composed of materials of different densities, it is necessary before and during the time of using it to occasionally stir it, or otherwise the mineral portions will settle at the bottom, and the oil and turps will float on the top.—*G. F. Budd in the Hub.*

I have tested various samples of rough-stuff as to their elasticity, by applying them to pieces of tin. Now here is a sample which can be applied to P. W. F. after it has a week's drying at a temperature of 75 degrees of heat. You see I may bend the tin as I wish, and the rough-stuff does not crack or flake, and it is not dry before that time. Here is another sample—this one dries hard over night; my finger nail makes no impression upon it, and it rubs well; but see, it is not elastic; it breaks off wherever I bend the tin. You see painters cannot be too careful in selecting and testing the rough-stuffs now manufactured.

I think the best way of all to try the absorbent or non-absorbent properties of your rough-stuff, and of those manufactured, is to apply the desired number of coats to pieces of plate glass; then paint them in the usual way, and hang them up exposed to the sun. In a few months you will then be able to distinguish, by reason of absorption or dullness of the surface, the porous and absorbent from the non-porous and non-absorbent grades.—*Capt. O'Connell.*

White lead, it is claimed, has the advantage of durability against the ammonia which is produced by the refuse matters of the street and stable. English filling and its perhaps equally good American imitations have advantages in several ways. They can be placed at less cost of time, and give a very hard, glassy surface but one more porous than that given by white lead, although this porosity may be due to lack of oil.

This filling closely rubbed will sometimes rise from the wood, loosened no doubt by the water which has passed through it to the wood cell-stuff. This indicates the need of more oil in the form of varnish or white lead; and as Mr. Gardner suggests, time for the filling to get dry of water. Wet filling may cause blisters.

Some painters and writers express their astonishment that a carriage after so many coats of paint will still show the grain of the wood. It should not be forgotten that varnish is transparent, and itself is an aid rather than a hindrance to the perception of the grain of the wood as it throws aside the white surface light, and in deeper coats reflects on to the grained surface more of the light passing through the outer coats. For these reasons wood which has been completely hidden by filling is no longer hidden when the varnish is placed upon it. It will be seen, therefore, that the more untransparent the coating the better it will hide the wood.

Color Coats.—A not infrequent mistake is made in mixing these coats with too much oil. If time allows, some oil is desirable ; and without much doubt the flaking off of varnish from color, and color from varnish, can occur from a too flat coat or too oily a coat. In the first place it should be remembered that colors with turpentine only give a smooth powdery surface, with nothing for the varnish to hold to. Secondly, if the color is fatty and after drying takes on a gloss from the appearance of not-dry oil on its surface, trouble may follow if a strong varnish is placed over it.

I am indebted to Mr. J. B. Hubbard, of the Emerson & Fisher Carriage Co., of Cincinnati, for the following incident in his large experience :

> The varnish of a carriage which had recently been painted was discovered to be so loosely united with the color that it could be scraped off with the finger-nail. The oil with which the color had been mixed was not purchased by Mr. Hubbard, and on examining it closely he discovered a fishy odor and a "fatty" condition which convinced him that the oil was at fault ; and having a small quantity of oil known to be pure he mixed the color with this, var-

nishing it with the same varnish placed upon the carriage. No flaking occurred, the varnish holding as well as it ever does.

Too much oil in color will also produce tendency of varnish to flake.

Mr. J. P. Thorn, of the Gosling Carriage Manufactory, relates an experience in point. He had mixed his color with some varnish. A little being left, however, he thinned it with turpentine to finish out. The varnish over the thick color was found to flake so as to be removed with the thumb nail. Those portions on which the thin color had been placed held the varnish as usual.

The turpentine in varnish may be a cause of trouble, but if it is this may be tested. Certainly the flaking off of *paint* seems in general to arise from too thin a layer, or some other effect of an excess of turpentine. Color and varnish so mixed do not flake, however, if the turpentine is good.

Varnish.—As far as possible it is well to avoid rubbing varnish ; and when using it to mix it with finishing varnish. The painter who tries experiments with turpentine, oil or any such substance, as mixture for varnish, easily fills his shop with mystery enough for a short lifetime of investigation. Use varnish made by the most reliable varnish makers and in general *as they make it.*

There is, however, an important modification of this rule, if, indeed, we should call it a modification.

Color and varnish is one of the most useful of devices for giving uniformity. There are, however, colors which will not easily mix with varnish, and the secret of using these and all others with varnish is to sufficiently thin the color with turpentine. So thinned, even Tuscan red can be used with varnish. In all mixtures of varnishes, however, the painter needs to know his materials well before making up for work.

I would impress upon every painter the necessity to test his varnish before using it, if time will permit. The demand for a quick rubbing varnish is becoming so great that varnish-makers are using every effort to reduce the time of rubbing, and to-day we have what are called two and three day rubbing varnishes. If it is the intention of the painter to do good work, he must not touch such stuff, for such varnish is miserable trash. Test it and see for yourself! Flow a sample of any of these varnishes on a piece of glass, and at the end of five or six days run the edge of a putty-knife along its surface, and it flies off like so much dust. Put it onto a gear, and in a little while after it is run out it breaks off, by reason of jarring, from the clips, rims and nuts; and when any hard substance strikes this varnish, off it comes, bringing with it the finishing coat. The priming, being then unprotected, is affected by the washings which the carriage receives, so that those places afterward become bare to the wood.

Now, as the foundation is laid, let me pass to the superstructure, and let me ask first, How shall that be raised,—with clear rubbing varnish, with black color and varnish or with black japan? We must select one or the other, so as to accomplish the desired end.

To accomplish this end I would most certainly give the preference to black japan, for the reason that it is superior as a rubbing varnish to any other that I know of; and when flowed over good *ivory black*, it is deeper than any other black known to carriage-painters. Moreover, this black japan deepens in tone from day to day. Compare, if you will, the color of three coats of japan, which has been applied to a board which has stood say for a year, and a freshly-painted board, and you will be astonished at the difference, for on the year-old board it has become so deep in tone that there is nothing in nature deeper or blacker. It is the practice to apply two coats of this varnish, a coat of clear rubbing varnish and a coat of finishing. Why not, I ask, put on a coat of black japan instead of a coat of clear rubbing varnish? You would certainly by this means get a still deeper color, doing away with the possibility of any brownness showing, even under the effect of a concentrated light. It is claimed that a coat of rubbing varnish is flowed on for the purpose of having the work wear better. But if that is so, why not put on two coats of rubbing varnish, which would make it wear still longer?—*Capt. O'Connell.*

As to the quality of varnish, its mysteries and difficulties, we must refer to other parts of the book. On running gears a *hard* varnish made with lead drier and considerable Zanzibar copal is desirable.

We strongly recommend placing in every shop the following list of "Don'ts." The *Coach Painter* deserves the gratitude of the trade for this list:

Don't use the bucket for a wash-basin, or the "shammy" for a towel.

Don't touch your work with sweaty hands.

Don't flood your floor with water; have it *clean and dry every time.*

Don't wash off your work in the same room you finish it in.

Don't fail to use plenty of clear, soft water in washing off, for if the work won't stand a thorough washing, *you understand why*, and will not look for a lasting job.

Don't apply your finishing coat, or any other, until you have completely cleaned your work, and are sure it is perfectly hard and free from moisture.

Don't let the pumice in corners and around and under the moldings escape your notice.

Don't apply a cold varnish on a warm job, or a warm varnish on a cold one.

Don't keep your varnish in a damp or cold place.

Don't overload your work by laying two coats in one. A full coat *laid on evenly is all-sufficient*, and will give you a finer looking and more durable job.

Don't work your varnish too long or leave it too soon. Become acquainted with it, and it will obey you first and last.

Don't pour your varnish back into the can taken from; it will cause you trouble. Have a clean can for the purpose, and use it only after time is given to settle.

Don't keep your brushes in oil or turpentine; keep them in the varnish you use them for.

Don't use any but the best rubbing varnish (it is the cheapest in the end), and follow it with the best finishing.

Don't you know that a job turned out with a *fine finishing* varnish over a *poor rubbing*—although it may please you for the time being—will soon return to you for repainting and revarnishing?

Don't attempt to be a varnish-maker by diluting your stock with oil or turps; don't meddle with it, but, if unsatisfactory, send it back to the maker, explaining the trouble.

To these negatives may be added Mr. Egbert's excellent positive rules:

1st. Sweep the varnish-room thoroughly (walls, ceilings and all surfaces) every time your work will permit; wash the walls and scrub the floors once a week.

For scrubbing, the long-handled brush having an arrangement upon the back for taking up dirty water and conveying it to the bucket is very convenient.

2d. Ventilate your room thoroughly before varnishing if the weather will permit, taking down curtains and dusting them *out of doors.*

3d. Keep your cup-stands, screens and all other things free from dust.

4th. Always have kindlings and coal (or better, coke) in the stove ready for any change of weather.

5th. Keep your brushes, dusters and cups in a tight cupboard outside but convenient to the varnish-room. Never under any circumstances use them for any other than finishing coats.

CHAPTER VI.

SYSTEM IN CAR SHOP.

A good organization is usually one which has grown up under the care of a number of minds. In writing about the organization of a shop, therefore, we shall naturally seek to combine a variety of methods, and, while disclaiming any originality, shall not try to give individuals credit because of the difficulty of so doing, coming at things in various ways and not knowing certainly to whom credit belongs, but thoroughly satisfied it does not belong to the writer.

It is well, even in small shops, to have a few rules and to have them plainly printed ; the danger is, however, that when one begins to make rules he makes too many. It looks ridiculous, and is worse than that for the shop, to see a printed rule on the walls which nobody pays any regard to, and yet, strange to say, these are the sort of rules which get themselves posted, probably because these rules are difficult to enforce, and so it is thought that some mysterious effect will follow their display.

Print and display no rules which cannot be and are not easily enforced, keeping rules which are difficult to maintain for the bulletin board, if you have one.

There is a great deal of art in what may be called *reserve* in rules and orders.

The man who knows how to be firm and persistent in a quiet way and in respectful language has a double hold upon his men ; they fear him the more because they thoroughly respect him. The blusterer and the boss who like to show their energy in their words lose one-half their power in losing the respect of their hands. One is never quite certain what a strong, quiet man is going to do about it.

Decision.—There is a good deal in having fixed principles, and being willing to stand by them. A lazy hand, a tricky talkative rogue, or a man with that sort of foul-mouthed wit which makes him to the other hands like an escaped inmate of a pest-house, ought to be weeded out at once. It wants, however, some discretion and some insight into character to know how to do this promptly yet wisely. It is not a question of wages at all, but of the influence of one low-grade hand on the labor and discipline of the shop; and the same may be said about good men. One ambitious, self-respecting workman, who has the push in him for doing a good job quickly, is worth much more than the work he alone accomplishes.

Accounts.—It is well to keep a thrifty oversight over all tools and materials, and to adopt some system of checks on all brushes and pots, etc., in use, and paint, oil and varnishes drawn.

Giving each hand a number, and a supply of brass checks stamped with this number, it is easy to keep this account, by hanging the checks on pegs opposite or under appropriate headings.

Brass checks have this advantage over a mere record (in chalk, for example), that although there may be a mistake about what has been taken, there can be no dispute as to who is accountable for something, and just what men are in debt to the shop for tools or other materials.

Where a mixer is employed, it is well to have a color-board, giving the various shades of color, with a number to each, which will be most certainly needed, so that no mistakes of misunderstanding may occur between the hands and the mixer. In case of doubt, the board can be consulted and used to indicate the color required.

The head of the shop will, of course, look closely after his gold-leaf, and if he keep a little account with his gold in order to trace the use of every book, it will increase rather than decrease the honesty of the shop. Laxity in accounts is almost a temptation to dishonesty.

Piece Work.—In the larger shops, as at Pullman and at Altoona, time work has been replaced by piece work. At Altoona, each piece of work is rated and the amount divided among those who perform it; at Pullman, a foreman becomes responsible for certain pieces of work, hires his own men, and generally works with them. The Pullman Company pay the men, and may refuse to accept any man hired by the foreman. The work is inspected by the master painter (who receives a salary) and only after the inspection of the completed job is the foreman in charge entitled to draw the balance due him. His men have been paid every two weeks, the balance is the amount of the contract price less their wages.

There is no doubt of the advantages of piece work over ordinary methods—the men do more and get more, and the master painter at Altoona tells me the men prefer to wait for a piece job rather than spend time on a job paid by the hour. We doubt whether the finer kinds of work can easily be done on this plan, but as a system of labor it promises much in the future in giving each man what he can earn.

Car Record.—At present the car painter has very little or no authority or responsibility beyond his shop. Cars are sent him when inspectors or superintendents or other officers care to send them, and the man who should at least be supposed to know more about paint and varnish than any other on the road must work under the disadvantage of throwing away one-half of his knowledge, namely, of the needs of paint and varnish as to care and renewal. Three chances to one, the painter has nothing to say about the washing of the cars. One hundred chances to one, the painter is not even consulted and has no care over any car or locomotive running on the road until it is sent to his shop.

Of course it is not possible to put the power of sending cars to the shop in the hands of the painter, but is possible to get his advice about the matter.

If the painter were charged with the duty of inspection of all passenger cars (and perhaps all locomotives) on the road, a report like the following could constantly be kept in the office of the superintendent of transportation, or whoever has charge of passenger cars. On a ruled sheet hanging in said office and entitled *Condition of Coaches in Respect to Paint and Varnish*, the painter could state, dividing the cars as to the importance of their needs into three classes, those cars needing varnish immediately, soon, or remotely, in their order of need ; (2) those cars needing repainting, divided likewise into classes, and stating whether the car will probably need to have its paint burned off or not.

A statement of the average and of the least time for doing each class of work should also appear on the same sheet, as a standard record.

This method enlarges the sphere of the painter without at all interfering with the responsibilities and jurisdiction of other officers. Probably it or some like method is the only one for securing economy in the repainting of cars.

The painter's position is a very hard one. His duties are the final ones on any piece of work, and about the time that piece of work reaches him, the need for it becomes pressing. He is, therefore, constantly subject to pressure, who of all the long line of trades can least safely hurry his work; for the painter is like the farmer—he must wait on time and the weather.

Time to the painter is not only money, it is good work, honesty, satisfaction of mind and dreams which are no longer full of cracked varnish and scolding customers.

Next to a piece of dry wood which will let the oil get a firm hold of it, nothing is so necessary for a good job as a little time for paint to dry.

To the New York & New England Railroad, the Pennsylvania Railroad and other shops we are indebted for these suggestions.

PAINTING A PASSENGER CAR.

In painting a passenger car, fix the attention on the important things, and distinguish them from each other.

These are:

1st. The protecting coats.

2d. The ornamental coats.

3d. The relation of every coat to those immediately above and below it.

The protecting coats of a passenger car are the priming and the varnish. Other coats than these are ornamental and not necessary for the protection of the wood. Protecting coats need oil to protect the wood, ornamental coats need oil only to bind their particles together. In hurried work lay out the plan of the painting to get all possible time for the protecting coats. Prime the car while still in the carpenter's hands, and at the earliest moment at which the work will allow.

Knots.—Cover these with a varnish of shellac or (better) gild them over with gold leaf.

Priming.—Use pure, thin oil. If the wood is not perfectly dry, put on the oil hot—150° or less. This is necessary, because if there is water in the wood cells, only a thin oil will get an entrance, and unless the priming enters the cell stuff, there is danger of the paint peeling off.

Whatever system or method is used, begin with a priming of thin oil, giving the wood all it will drink up. *The less oil left on the surface, the less danger of cracking*; no oil, however, need be wiped off. Prime both sides of the wood, the inner side with two coats. On the surface to be painted, never, under any circumstances, put on more than one coat of priming, *i. e.*, more than one oil coat. With one coat of priming deep in the cells of the wood, the work of *protection* of the surface is completed until the varnishing.

It is well to use a thin drier, made with red lead or borate of manganese, with the priming. Gold size may be used, but it is expensive, of course, and much of it makes oil brittle. The priming must be dry before any other coat is put over it; a slight expense here is often a great saving.

Oil will dry in clear weather and in a warm shop in 48 hours; with a little drier added, in half this time. It should be dry, without the least "tach."

Putty.—Use a good putty which will not shrink—"panel putty" the best. Cracks, crevices and holes should be filled solidly full, leaving no air space below the putty and no putty on the surface, but a solid body of solid putty even with the surface.

There is special danger in case of screw and nail heads. If air space be left above these they will rust, and the increasing pile of rust will gradually raise a hill on the surface of the paint by pushing up the putty.

Scraping Filling-Coat.—This should be the next coat in an economically painted car. There is economy of labor, material and time in using a leveling coat or rough-stuff which may be scraped, and the result on light colors is entirely satisfactory, and to be recommended even for dark colors.

A good material for this coat is keg white lead (6 lbs.), whiting (7 lbs.), mixed thick with coach japan and ground in a paint mill. For use, thin this mixture with turpentine to the consistency of plaster of paris as used by plasterers—*i. e.*, thin enough to work easily, and so thick as not to run. It should be put on with a leveler or scraper. A good tool may be made by fixing an old saw blade by its teeth into a wooden handle.

This is an ornamental coat. Its purpose is not to protect, but to level the surface of the wood. Therefore, none of it should be left on the plateaus, as the children would say in the geography class. It is not to be left on the higher portions of the surface, but used merely to fill the hollows to a level with these. Keeping this rule in mind, scrape the surface to an even plane, level with the highest level of the bare wood. Give 24 hours to dry, and put on a second coat, scraping down to the level of the highest portions of the bare wood, and filling up all hollows to this level. Give 24 hours to dry, and sandpaper with No. ½ paper. Dust, and the car is ready for color.

Color Coats.—Give three coats of color mixed with turpentine and drier, enough oil (only) being used to prevent the color from rubbing off. Oil in color coats commonly means a cracked job—not immediately, of course, although it may come sooner than one would expect. Each coat of color should have 24 hours to dry.

Color and Varnish.—The advantages of a coat of mixed color and varnish are several: (1) It gives a good and safe surface on which to stripe. Striping cannot safely be done on flat color, because the slightest touch of the hand remains as a permanent mark, which comes out more clearly after the car is varnished, and it is almost impossible for the workman to avoid touching the car while striping. For this reason, rubbing varnish is used by those who are convinced that it is an injury to a lasting surface. A coat of mixed color and varnish may be rubbed down with a bunch of hair or moss, and will serve quite as well for a striping surface as rubbing varnish.

(2) A coat of color and varnish makes a half-way coat between the weak oil coat below and the strong varnish coat above. Uniformity in the strength of oil coat is principle "B" in the prevention of cracking of paint and varnish.

In mixing color and varnish, however, one must know what one is doing, and what he is doing with. Tuscan red, the Pullman color, or chrome yellow (mixed with other colors) cannot be used in this way with varnish. On the other hand, chrome yellow (by itself), all white-lead colors, ochres, greens, drabs and vermilion (genuine) will safely and advantageously mix as color with varnish. These facts are given as *facts*, out of a long experience in car-painting. In mixing color and varnish, one uses, of course, the color as mixed for color-coats with an equal amount of good finishing varnish. So thin this mixture with turpentine as to leave on the car only an egg-shell gloss—*i. e.*, a dull, half-lustreless gloss, like that on the shell of a hen's egg. Allow 24 hours to dry.

Striping.—Rub off the gloss from this color and varnish coat with a bunch of dry moss or horse hair. Then stripe and gild. Mix colors for striping by the same rule as colors for color coat. Oil in striping colors will often show itself on the surface of the finished car by the cracks paused by the pull between it and the varnish.

A man who is a man will resist the temptation to slyly run some oil into his pot, because the flat color does not work easily, and he is a little weary. The man who prefers his ease to doing a good job will pour in the oil.

Stripes and ornamental work should be allowed 24 hours to dry.

Finishing Varnish.—The car is now ready for its first coat of finishing varnish, which should be an elastic (oily) varnish and worked out as a spare coat. It should be allowed at least 48 hours to dry. Then should follow a second and fuller coat of the same varnish, and the car should be kept out of the sun but well exposed to all breezes for a number of days.

Using light colors, only an expert would detect the difference between a car painted by this method and one with the much more expensive and less safe finish of rubbed rough-stuff and rubbed varnish.

A first-class job can be turned out in 12 or 15 days; hardly in less time if a durable finish is desired. Additional time between coats will give additional safety.

In fact, 12 hours or a day longer to every coat would, perhaps, pay in the final outcome of work.

METHOD A.

Time required for each coat to dry:

	Hours.
Priming (with drier)	24
Scraping filling coat (2)	48
Color coats (3)	72
Color and varnish	24
Striping	24
Finishing varnish (2 coats)	96
Total	288

METHOD B.

Prime as directed.

Rough-stuff.—This is merely a leveling coat. Whatever material is used is put on to be rubbed off, in order to have a level surface, and one may choose from a variety of substances. Silica, ochre, umber, pipe clay and several prepared surfaces are rough-stuffs which have special merits, and may be used with advantage. It is well to bear in mind, however, that a porous substance or mixture may soak up oil from outer coats and injure them as well as itself. A good rough-stuff is made by adding half a pound of keg white lead to two pounds of silicate, the lead serving merely to bind the particles of the latter substance. Too much lead will give too hard a surface.

No oil or varnish should be used with this mixture, but it should be thinned with japan and turpentine, and some very finely ground pumice stone rubbed through it.

The writer would advise experiment with the patent surfacers, which are still under trial. They have no doubt proved a saving of time in many shops. They are also advantageous, as they contain less lead. Painters should endeavor to make their calling as healthy a one as possible, by experiment with substances which will replace lead. But it must not be forgotten that experiment requires attention to all the qualities of a substance, durability as well as convenience ; although one may easily sacrifice money and time to mere durability, which is not called for.

With an early start, two, or, if thought necessary, three coats of this surface may be put on in one working day. Next morning paint over it a *guide coat* of lamp-black and turpentine, bound with a little Japan. This guide coat serves to show by its presence on low portions of the surfaces where the low spots of surface are. It, in this way, saves unnecessary rubbing, by guiding the eye, and should be entirely rubbed off. After thorough rubbing, should any black spots be left (remnants of the guide coat), these should be puttied up to the level surface.

Rubbing Rough-stuff.—Simple as it may appear, there is art in rubbing rough-stuff and varnish. The sponge filled with water should be held in one hand in such a position as to feed the pumice stone which is rubbed against the surface with the other hand. Artificial stone may be used for the early stages of rubbing, the finishing being done with the finer natural stone.

The filling coat should be thoroughly rubbed away to a level, which should be as low a level as possible—that is to say, as little of the rough-stuff should be allowed to remain as possible. It requires the labor of two men for six days, or four men for three days, to properly rub the rough-stuff on a car. Also eight pounds of pumice stone, together with a considerable amount of waste material used in the filling coat.

Also, it is an odd thing to do, to undertake with great pains to protect a car from water, and after only the first step in this protection to industriously rub water into its surface during a whole week.

When the surface is rubbed to a perfect plane, sandpaper* with No. ½ paper, and dust the corners with knives, brushes, etc., being specially careful not to forget the grooves of the moldings. The surface should now be carefully examined; no more leveling should be necessary after this coat.

Color Coats.—On this surface is placed the color in three coats, mixed as directed in method A. Over the last coat should be placed a varnish composed of one-half rubbing varnish, one-half finishing varnish. In

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* Keep the mouth closed and breathe through the nose while dusting with sandpaper, to avoid the lead particles which otherwise may get into the mouth.

making such a mixture, the painter will, of course, make sure that he knows his materials. Not all varnishes will allow of mixture with others. Experiment must be made in advance. Rubbing varnish as usually made contains too little oil.

Color and Varnish.—Before this coat of mixed varnish, however, it is better on all colors which will allow of it (see method A) to mix color and rubbing varnish. This cannot be done when Tuscan red,* the Pullman color, or any *mixture* of chrome yellow is used. An advantage of mixing color and rubbing varnish, in addition to those already given, especially where rubbing varnish is used, is lessened danger of a spoiled job in case the varnish is cut through in the rubbing. Allow 24 hours to dry before rubbing.

Rubbing Varnish with Pumice Stone.—Great care must be taken in rubbing varnish, not to cut through the varnish to and through the color. This is especially easy to do about moldings and on sharp corners ; in rubbing one's mind must, so to speak, keep in one's fingers in order that danger may be *felt* and avoided before it is seen. One can spoil a good job of painting in a moment by careless rubbing.

After rubbing this coat of color and rubbing varnish, striping is in order.

Striping and Gilding.—Striping should be done in flat color as described in method A. It should be allowed 24 hours to dry, and the coat of *finishing and rubbing varnish mixed* should be put over, thoroughly rubbed and the gilding laid on it, if any gilding is to be done. Gilding should always be laid as near the

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* If plenty of turpentine be used it may be done. Plenty of turpentine is the secret of success in such mixtures.

surface as possible, as a thickness of varnish over it gives it a brassy appearance.

Finishing Varnish.—After the rubbing varnish, two coats of finishing varnish should follow. Before varnishing, the painter will carefully clean the surface of dirt with bits of pumice stone, using a water tool to remove the latter. A bit of pumice in a varnish brush can do a deal of damage.

Time required for Coats to dry by

METHOD B.

	Hours.
Priming (with drier)	24
Rubbing rough-stuff, time near one week	144
Color coats (3)	72
Color and varnish	24
Striping	24
Rubbing and varnish	24
Two coats finishing varnish	96
Total	408
Method A	288
Difference	120

It will be observed we have made no allowance of time for rubbing the varnish. This has been done purposely in order to give the full advantage in the estimate to the longer method.

Repainting Cars.—Directions for repainting will be confined entirely to what shall be done after the painter has made his decision as to the method he will follow.

The painter must exercise his own judgment as to frequency of repainting, and whether he shall burn off the old paint or lay new coats upon the old. Repainting often, the latter course will be possible, and if pursued with judgment, it will seldom be necessary to burn off a car. On the other hand, if the period between repaintings is lengthened, burning off the car may become the rule—we do not say the necessary rule. It is not necessary to burn off paint which is not cracked in deep cracks running through a number of coats or to the wood. Merely perished varnish or varnish cracked in fine cracks to the color are no obstacles to repainting. They may even be an advantage. If they are rubbed out, as they can frequently be, a better and more lasting surface for paint will be found below them. It should not be forgotten, therefore, that repainting on such a basis costs about one-third less than the removal of the old paint and an entirely new coating.

Let the painter, therefore, count the cost, the saving in the time of the car and in labor of repainting as against the chances of the work holding out.

We have known of all of the cars of a road being repainted year after year, with excellent result—a burned off car being an exception and the appearance of the cars unusually good.

On the other hand, roads which carefully count expenses, burn off and repaint very frequently. The matter is one which can be decided only after careful consideration ; and we shall express no opinion on the matter further than to say that a system which is based on skill and economy would naturally seek to save the old paint, since it better protects the wood from moisture. When wood has become very thoroughly dry, it can take up a heavy load of moisture through a thin coat of paint, and crack both itself and the paint above it. On the other hand, new paint over old has greater tendency to crack than over coats of its own age, if they have been properly dried.

The most skillful work is done by repainting on the old foundation, but not every painter will find this the economical method.

REMOVING PAINT.

Burning off by means of hot irons or by gas jets is the common and almost the only method in use in car shops. The use of gas is by far the more economical of the two fire methods, because of the great saving in labor.

Whether a chemical method could be used to more advantage than either of these is a question to be solved.

A large majority of our railway paint shops are so situated that gas is not to be had, and the paint must be removed with such appliances as we have at our command in the shop. We may have employed different methods, but it is for us to consider at this time which is the most approved plan, which can be best determined by comparison. My first experience in taking off old paint was by the application of hot irons. You all know what those were—5 by 8 in. in size and 2½ in. thick. This was a tedious and not very safe method ; we found it no boy's play to heat and hold these irons while another man did the scraping. By this old plan the cost was $30 a car for burning and scraping ready to paint, and wages then were about two-thirds what they are now.

A charcoal furnace was used in some shops, but was not practicable for car work, it being best adapted to burning off on locomotive tanks. It is still in use with good success, although steaming the body of the tank is a better and quicker method when it is convenient to apply it. Some improvement was made when the spirit-lamp was introduced, Wakeman's being the first I had any knowledge of. It did the work well, one man being able to burn and scrape ; but the most serious objection to this lamp is the expense of running it, four gallons of alcohol being required to burn off a car and costing about $10, and a large part of the time was spent in re-filling the lamp, as it would run but 1½ hours.

I might mention other methods of removing cracked paint. Many have been tried and found either too slow or injurious to the fresh paint which followed their application. Caustic soda, potash, concentrated lye, ammonia, carbolic acid, lime, wood naphtha, the benzine paint burner, and others of a similar nature, are almost worthless at the present time, although they may have answered the purpose when nothing better could be had. Soaking or cutting the paint with alkali or acid is not a safe method. And supposing it were safe, wherein lies the economy when the burning is much the cheapest?

The gasoline lamp is not yet in general use, but I have used it for four years with the best of success. The expense of removing the old paint has been reduced fully one-half. It gives a steady heat and burns freely. A lamp holding one quart will burn 3½ hours. One man can burn and scrape, and a car can be burnt off and cleaned ready for painting at an expense of $15. This method is superior to gas, the flame is stronger and the cost far less. You also have the advantage of being able to take the lamp to any part of the shop, which cannot be done conveniently with gas.

When we burn off a car body the wood battens are generally removed and new ones put on, although we frequently burn them when they are in good shape, especially about the middle rail of the body. Care is required in scraping off the blistered paint so that no gouging or scratches be made. The surface should be scraped clean, then sand-papered well with block and No. 1 paper before applying the priming coat. Scraping knives should be 1½ or 2 inches wide, stiff in the blade, square at the point, not sharp, but blunt; run the knife under the blistered paint, followed up close to the lamp. If care is exercised, there is no need of making dents in the wood, and the heavier the body of paint on the car the better it will peel off; if the paint is very dry, give it a coat of raw oil previous to burning, allowing some time for it to soak into the paint. This will cause it to blister much easier, and it will scrape off cleaner from the wood. This lamp will burn in any position, will throw the flame wherever wanted; it can be spread in any shape; you may burn overhead on the roof projections as well as on the side. In fact, it is the most satisfactory and economical means of removing old paint that I have yet seen.

I shall have very little to advance on the methods of removing cracked or decayed varnish from the inside finish of the car. The best plan is by scraping the varnish off. This is the most practical way and makes a good job if well done and sandpapered properly ; but too often inexperienced men, in scraping, will leave the surface in a bad condition. This should be guarded against, and the men who understand the work put to it. A better foundation will be left after scraping than when the work was first turned over to the painter from the hands of the wood-finisher.

Other methods have been tried, and I have tested several. Spirits of ammonia will remove the varnish, but it requires time and repeated applications to reach the foundation ; then when it is done, you have got a rough surface which takes a large amount of labor to prepare it for varnishing, and any preparation of this nature has a tendency to destroy the richness of the natural woods. But supposing that any of the preparations offered for this purpose should not stain or injure the wood ? Where has any saving been made when the varnish can be scraped off and the surface left in a good and dry condition at less labor and expense than by any other method ? I am satisfied from my own experience that scraping is much to be preferred to any other plan that I know of.—*Robt. McKeon.*

We are doubtful about the wisdom of using gasoline in the paint shop. Otherwise we accept the above. The secret of using ammonia is to wash with abundance of water.

After the paint has been entirely removed, the repainting is in all respects the same as a first painting, with the exception of the priming. Prime with white lead, oil and turpentine. Considerable differences will be found in the wood of burned-off cars, the priming in some still remaining, in others having disappeared in a considerable measure. This measure has, therefore, to be gauged, and no more priming given to the work than it needs to fill the surface cells without leaving a coating of oil on the surface. Such a coating would endanger the paint above it, and, therefore, it is well to make a previous experiment by lightly priming part of a panel, leaving it over night, in order to determine what quantity of oil it will drink in.

The only rule necessary for repainting a burnt-off car is, adapt your priming to the condition of the surface. If already filled with oil, it is only dangerous to add more; if the wood cells contain little oil and will take up more, more is needed. If the surface of the wood remain glossy after the experiment recommended, then add one-half to one-third turpentine to your oil. If the oil on the panel experimented with has been drunk in by the wood, add less turpentine, but in nearly all cases add some turpentine whenever a burnt-off car is to be painted. *Prime the car with white lead, oil and turpentine, adding a little color if a dark color is to be used as color coats.*

Repainting Over Old Paint.—1. Examine the entire surface of the car carefully, removing all loose paint, especially the loose ridges left here by shrunken moldings and panels. If the surface varnish is cracked, it may be best to remove it entirely—*i. e.*, the mere surface varnish.

2. In all cases sandpaper with coarse sandpaper, in order to make a tooth in which to give the new paint a foothold. The interior of the scratches made by the coarse sandpaper is softer than the hard, glossy surface, and the new paint will unite better here with the old than it can do on the harder and smoother surface.

This is important—as important as scarifying an old wall before plastering it anew, and for the same reasons.

3. Mix your priming, white lead,* oil and turpentine to the condition of this surface. If it is dry and hard, add more oil ; if it has still the lustre and a little of the softness of new paint, add more turpentine and less oil.

This is the finest point in repainting—to judge of the exact amount of oil needed to make two coats—old and new—unite into one which will not crack the coats above, and yet hold firmly together as one. If much oil is used over an old coat which is still oily—as an English varnish generally is (for example) even after three years—the result will be disastrous.

Even a skillful man cannot always hit his mark, but care and observation will reduce the number of failures to a few. The principle is, unite the two coats —old and new—as only oil can unite them, but to use no more oil than is necessary to do this, because if there is oil in the old coat and oil in the new, the result will be a strong coat, which, contracting, will injure all coats above it.

This oil gives elasticity to the coat, but it makes it a dangerous one to repaint upon, and for this reason, English varnish is more difficult to "hit" in this respect than nearly all American varnishes. The writer, by placing a piece of oil paint on end under the microscope, has seen the coats of a frequently repainted car drawn up into gentle waves by the contraction of the stronger varnish. And yet cars may be repainted in

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* Add either Venetian or Tuscan red to the white lead, as priming, if Tuscan red is to be used as color, Indian red under Tuscan red will darken it.

such manner as to last many years without cracking —this being done again and again, until the car is covered by many coats solid and perfect.* After priming, the car is puttied up and re-surfaced with scraping filler, etc., the entire process being like that of a first painting.

THE INTERIOR WOODWORK OF CARS.

The finish of the interior of cars is a matter of much more importance than that of the exterior. The outside of a car needs a neat protection, the inside simple and tasteful decoration.

Elaborate decoration has its value, but is less appropriate ; and is often distasteful if not done by skilled hands.

THE WOODWORK.

There are three kinds of finish for woodwork.

First Coat of Varnish.—Oil finish gives a fine, durable surface.

Fill the wood (see Appendix), using color, if necessary. If starch dissolved in turpentine is used as a filler, rub it well into the wood with an old brush, let it remain for 15 minutes, and rub off the surface with waste or a rag. Rub across the grain of the wood, and follow strictly the course of the fibres, in order to leave the filler in the pores of the wood. Allow the filler 12 to 24 hours to dry, then give a *spare* coat of good rubbing varnish. Such a varnish should not contain much oil, but be made of the best copal, if possible to get it.

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* Twenty coats of paint in 30 years have been put on a car, and no cracks perceptible. The car referred to in the text had English varnish in one or two under-coats.

Allow 24 (better 48) hours to dry, and then sandpaper with No. 0 paper. Be careful not to cut through the varnish on the corners.

Second Coat of Varnish.—Make this a heavy coat of the same rubbing varnish, and allow it 24 hours to dry.

Then rub with pumice stone and water to a perfect surface.

This surface, well cleaned with oil, gives a good lustre, and the oil in some measure protects the outer coat from overhardening or contracting.

A third coat of rubbing varnish, treated as the second coat (the second coat, of course, getting no oil), gives a still finer surface, but it must be remembered that unless time allows for the thorough drying of each coat, every additional one increases the danger of cracking.

Renewal.—At the end of a half year, it is wise to renew this surface by rubbing it down with pumice stone and water, and again with raw oil. Or the oil, without using the pumice stone, may be carefully rubbed in (not too much, or the surface will become sticky and dirt-catching). If skilled hands can be spared, this occasional treatment with oil will preserve the varnish, but careless treatment is worse than none, as it is sure to leave too much oil on the varnish. No polish is so good as pure raw oil, sparingly used and well rubbed in.

If the surface is at any time discovered to be cracked, it should be carefully examined, and if the cracking extends only through the outer coat, this may be rubbed off, and the oil applied as before.

If a new surface is wished, add another coat of the original varnish, and oil as before.*

The interior varnished surfaces of a large number of cars are more or less badly cracked, and the difficulty lies not in the wood, but in the varnish and the method of applying it. Too quick and hard, and therefore too brittle, varnishes are used. A quick varnish is, however, necessary when rapid work must be done, but such a varnish may easily cost the car a day of its time and the cost of a day's time besides. The expense of rubbing down the inside of an ornamental car to properly remove cracked varnish is worth as much as a day of a car's time, estimated at even a high rate. Besides, once removed, so good a surface and finish can never be got on the same surface of wood—not, at least, without great labor.

It is the most expensive sort of economy, therefore, the penny-wise-pound-foolish sort, which puts a short-lived, expensive finish on the outside of a car and a cheap one on the inside. The purchasing agent who has his road's interest at heart will look out the very best and most durable "A" selected kauri or copal varnish for the interior of cars. We are glad to say that we know at least one purchasing agent who has sought to apply a test to varnish before purchasing, but he belongs to a road on which economy is a first principle.

But a good varnish hastily applied, one coat on another, and especially applied too often, will surely crack. "If you have good oil," said a great painter of the olden time, "you can make a good picture;

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* If the varnish has had much oil, it is better to rub down with pumice stone before giving the new coat.

and if you have poor oil you can still make a good picture." This is hardly true of varnish; nevertheless, in painting and varnishing, the main things are knowledge and skill and time.

DIRECTIONS FOR THE APPLICATION AND CARE OF VARNISH ON THE INTERIOR OF CARS.

1. Get the best selected kauri, or, possibly better, good copal varnish.

2. Allow coats all possible time to dry, and plan for this the day the car comes not merely into, but to the door of the shop.

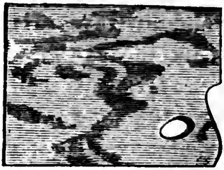
3. A little oil put on by skillful labor once every four or six months will preserve the surface of the varnish.

4. Do not varnish a surface oftener than necessary. Rub out cracks with pumice stone, and apply oil wherever possible.

5. If very much hurried, put on less varnish. Oil the first coat, and let the car go with that, if necessary. If complaint of finish is made, show cause. A second coat can be added on an odd day, but it should bear a family resemblance in composition to the varnish already on.

Patent Diamond Oil Finish (*without varnish*).—This is in every way the most economical finish for a car, although I am doubtful whether it is so well adapted to thin veneers as a varnish. There may be other oil finishes (not varnishes under that name) in the market.

Fill as for varnish; 24 hours to dry. Over this put on the first coat of oil; finish with a brush. Allow an hour to dry, and give a second coat; another hour and a third coat. Give three or four coats and rub the last coat with pumice stone and oil (no water used). The job is then completed, and will never need to be done over, for the surface will not crack; the lustre, which is not bright at first, will grow brighter with every new year. For the first two years it may be well to add a coat of finish and rub down with pumice stone, but thereafter nothing will be needed but rubbing down with oil and pumice stone.



CHAPTER VII.

DESCRIPTION AND TEST OF PIGMENTS.*

Pigments are colored powders, insoluble in water, which, when mixed with size, gums, oils, or varnishes, form paints. They are derived from both inorganic and organic sources. Under the former are included minerals and such chemical products as owe their coloring power to metallic and other salts; the latter derive their tints from animal or vegetable sources. As a general rule, the latter are more fugitive than the former. Some pigments are opaque, some semi-transparent, and some transparent. All these qualities are useful, especially to the artist, and depend for the most part on the aggregation of the particles of the pigment. The same body, chemically speaking, may vary considerably in these respects, according to the mode adopted in its preparation. When ground with oil or varnish some pigments have the quality of quickly oxidizing the vehicle, or allowing of its quick oxidation, whilst others retard this oxidation. They are said to be good or bad driers, accordingly. With bad driers artificial aids are resorted to. Among the substances employed as siccatives are acetate of lead, lime, sulphate of zinc and oxide and borate of manganese. Other substances have this siccative property, as burnt alum. This subject opens out for the chemist a large and remunerative field for investigation, and the direction in which this should be carried on seems to be that of the state of hydration of the pigments and their hygroscopic character. The good driers now in use, unfortunately, in most cases interfere with the delicacy of the tint of the pigment, while those which do not are inferior in siccative properties.

Pigments should invariably be fine in texture. This quality is brought about, in such substances as are not naturally in fine powder, by grinding and levigation; but some substances formed by precipitation are already in the form of impalpable powder. Millstones arranged in different well known ways are usually employed for this purpose. The material is ground in a stream of

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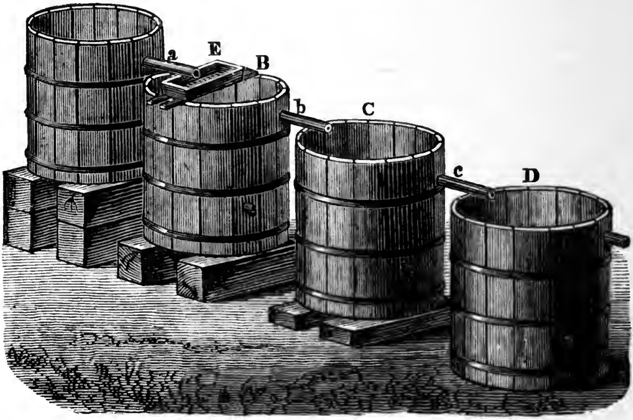
*Prepared under the supervision of ISAAC WYMAN DRUMMOND, E. M., Ph.D.

water, which carries off the fine portions into settling tanks arranged in succession.

The rougher grains are deposited in the first tanks, and require regrinding; the lighter parts remain longer in suspension in the water, and flow on to larger tanks, where they are deposited after some time of rest. There are also other methods of grinding, a description of which hardly comes within the scope of this article. When pigments are intended to be made into oil paints, it is generally necessary to dry them after grinding. With many substances great care is necessary in this operation, as an elevated temperature either destroys their tone or materially changes their character: the carmines are an excellent illustration of this. The best method of heating drying chambers is that supplied by Perkins, as by it high and regular temperature can be obtained. The use of the word *body* in connection with pigments is somewhat ambiguous. When applied to opaque pigments, such as white lead, Naples yellow, etc., it is usually understood to signify density and covering power; when applied to transparent colors, as Prussian blue, etc., it would seem to mean tinctorial power.*



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* The above was probably written by Prof. Barff, lately Professor of Chemistry to the Royal Academy of Art (London). It is preferred to use his language rather than repeat here statements frequently made.

It is necessary here to speak of but three of the conditions in which pigments are sold.

In Dry Powder.—The requirements are purity and fineness of grain. This last quality depends in the natural earth colors on the care with which they have been ground and the thoroughness with which they have been washed. Test may be made by crushing the article between the fleshy part of the fingers, or by rubbing it on a stone or glass with a knife. A more delicate test is given by rubbing a little of the pigment between the thumb nails. On the fineness of grain depends not only part of the coloring power of the pigment, but also somewhat of the softness and purity of its peculiar tone.

In Oil.—It is important that the oil be good, and that, for the best stability of tone, too much drying oil or drier should not have been used. Finally that the mixture, even if shut up in an air-tight tube, should not be of too great age. Bouvier points out that such old tube colors change to brownish shades.

In using prepared colors two precautions are necessary. The turpentine used should be of known purity, and as far as possible its use should be avoided when white lead is used with the finer lakes.

In preparing colors many precautions need to be taken, but when these are provided for the result will be more reliable. Some knowledge is needed of the characteristics of each pigment, but this is precisely where the early painters were superior to all modern ones, due to the fact that they were so familiar with all the processes of the manufacture of their paints. At the same time it is a mistake for the painter to suppose that this knowledge is to be obtained by mixing all his own colors; there are many, at least, which it is better to allow the manufacturer to prepare. (See close of chapter.)

Method of Description and Tests.—The method will vary with each color, such an arrangement as seems required by that more vital point peculiar to the pigments of each.

Chemical reagents will only occasionally be used in testing pigments. Nearly all pigments can be tested as to more important qualities by mixture with a white substance. The best French zinc white is perhaps the best substance for this purpose; 5 per cent. of the pigment and 95 per cent. of the zinc, the pigment being first rubbed up with a little oil and then mixed with the zinc. It is well to make a comparative test of appearances with a standard sample, mixed in the same proportions with zinc.

Qualities to be observed are, the weakness or strength of the diluted color, its richness or poverty of tone, and, in the case of white lead and the ochres and all those pigments which must be used as ground color, the amount of translucence. (See page 35.) Glass is therefore the best substance on which to place and compare the pigments; the layers of paint compared should be of even thickness.

Five grains of pigment and ninety-five grains of zinc are convenient quantities. Other white substances may be used, as we have indicated, in individual cases; for chrome yellow, Paris blue is the preferable dilutant.

Chemical tests: These are difficult and very often unsatisfactory; only simple ones have been given.

Care is needed in using such dangerous acids as nitric, sulphuric, muriatic, etc., and especially in keeping them in a proper place beyond the reach of ignorant persons. They should be properly labeled.

The removal of oil from pigments in oil is a tedious process, but is a necessary one in testing those in oil by chemical reagents. A little of the pigment must be washed three or four times with benzine, using a fresh quantity for each washing, until the benzine, evaporated by very gentle heat (in a watch glass, for example) gives no fatty residue. The pigment may be dried on filter paper, and is ready for test.

The coal-tar colors are becoming both useful and dangerous colors, as regards adulteration. The painter should observe carefully their lustre colors (colors seen by surface reflection), and become familiar with their qualities, which vary greatly. Tests for pigments due to changes of tone by artificial lighting have been given where possible.

As a rule the painter will not need to use chemical tests, but where this is necessary we advise him to seek the aid of his druggist.

BLACK.

A black (usually carbon) may be more or less opaque or transparent, and therefore have a deeper or brighter tone or color, and cover more or less well than another black. Its tone may be bluish or reddish, violet or brown, stronger or milder black.

	Quality.	Tone.
Lamp black..............	Greatest covering power.	Slightly violet.
Ivory "	Intense.	Moderate cold mild black.
Bone "	Transparent.	Warm reddish brown.

	Quality.	Tone.
Blue or vine black	Beautiful.	Slightly bluish to gray.
Frankfort "	"	Slightly bluish to gray.
Purple black (from madder)	Purple.	Purple.
Prussian black or Black from Burnt Berlin Blue	Intense.	Beautiful blue.
Coffee black	Mild.	Bluish.
Paper "	Very mild.	Bluish gray.
Cork "	Light.	Fine bluish.
Spanish "	"	" "
Black ochre		
Prussian black ochre	Common.	
Earth black	Poor.	
Peach or almond stone Black	Intense.	
Black	Manganese.	Brownish.

Drying Qualities.—The blacks all dry slowly. Bone black very slowly ; ivory black somewhat better; lamp black, slowly ; Prussian black, coffee black and paper black dry with fair rapidity.

Ivory black requires 125 parts (one and one-fourth of its weight) of oil to bring it to a paste. The amount of oil in the black is, therefore, one reason of its slowly drying quality.

They should not be mixed with too much oil for out of door work, as there is a tendency to crack in such a quantity of oil—varnish goes better with blacks. If thinned with too much turpentine, however, black "rubs up," especially when varnished.

Ivory Black (Horn black, etc.)—Consists of very finely powdered calcined bones ; it should have no lustre, as lustre indicates the presence of fatty matter ; and it is important that the powder be very fine. When not sufficiently burned has a brown tone and dries badly. It has less covering power than lamp black, because its particles are not so fine, and care should be taken to purchase of those who are able to command sufficient mechanical power and proper apparatus to reduce the grains of the bone coal to sufficient fineness.

The value of the ivory of the elephant for the manufacture of black consisted in its freedom from fat; other *hard* bones as free of fat will produce as good black. Changes in ivory black color may arise, as Mulder has pointed out, from soap-making, between the carbonic acid, acid phosphoric acid, lime and the oil producing a red soap, giving the color, in time, a brownish hue.

Some of the best ivory blacks are made from ivory chips; the average ivory black from bones which have been treated with muriatic acid, the black often requiring some artificial color to perfect it.

Ivory black with raw umber gives a series of neutral grays; with Vandyke brown as glazing color gives good shadows (Muckley).

Drop Black is ivory or bone black, blued with Prussian blue.

Bone Black is a cheaper article, made from a poorer quality of bones than ivory black.

Charcoal Black is a finely powdered charcoal, beechwood charcoal giving the handsomest color. It has less covering power than lamp black, but is a pure black and mixed with white gives bluish tones rather than the brownish and grayish tones given by lamp black. It is largely manufactured in Sweden and under the name of Swedish lamp black, much used in Russia, Germany and Holland for metallic roofs, gutters and gutter pipes.

Blue Black made from vine stems is a better quality of charcoal black.

Frankfort Black is a name which properly belongs to a black made from wine lees and other substances from grapes which contain potash. It has the same qualities as coal black, but greater covering power; there are, however, many other sorts of black sold under this name.

The blacks from fruit-stones have the same qualities as Frankfort blacks.

Coal or Shale Black **is a slaty anthracite coal.**

Lamp Black owes its great covering power to the fineness of its particles and requires very little or no grinding. The best is made from the gas oil wells, is in very fine powder and is higher in price than common lampblack. It requires thirty to fifty per cent. of oil to bring it to a paste.

In rubbing the lamp black, wet and mix with a little alcohol previous to adding water.

Black Lake is a lamp black blued with Paris blue, or it may be with blue aniline in shellac varnish ; so prepared it is blue in thin layers, but in thick layers black.

As prepared in oil, blacks may be proved by heating or distillation in a porcelain vessel ; and if a white precipitate remains which is dissolved by nitric or muriatic acid, there is bone in the sample. If the white precipitate remains undissolved, it is probably barytes. If the precipitate is of dark color, it indicates some mineral black. Pure graphite mixed with oil may be known by its metallic lustre. Graphite, it is claimed, is a valuable color for ship's black ; but how much of the real article is in the market it is difficult to say.

The best test for the quality of lamp black is to place the powder on a piece of not thick, porous, white paper, pouring a little ether upon it until the paper is fairly soaked with ether percolating through the black. If on the evaporation of the ether and the removal of the powder, the under side of the paper appears fatty, the black is of poor quality.

Lamp black may be tested by weight, as the black is very much lighter, bulk for bulk, than any of its mineral adulterants.

Its covering power is very great and it may be tested by mixture with white lead, comparing the mixture to a similar mixture of white lead and a pure sample, using the same proportions. The purer and less "foxy" (red) the gray, the purer and better the lamp-black.

WHITE.

Lead Whites.
White lead.
Kremser white
Cremnitz "
Blanc d'argent or } pure white.
Silver white
Flake white in flakes should be pure.
Crems or krems white
Ceruse } less covering power.
London white,
Nottingham white,
Sulphate of lead (little covering power)
Sublimed white lead (sublimed sulphate and oxide of lead) cream color.

Patterson's white or
Oxychloride of lead } affected by water.

Zinc white.—
Vieille Montagne zinc white (the best)
American zinc white } most durable in purity of color of white pigments,
Chinese white

Patent zinc white (sulphide of, with baryta or strontia).
Fulton " " "
Charlton " " "

Barium Whites may be artificial or prepared baryta rock.
Barytes (natural sulphate of barium) (small covering power.)
" artificial (greater " ")

Barytic white
Permanent "
Blanc Fixe
Constant white
} all the inclosed should be artificial sulphate of baryta, which is less crystalline than the natural article (probably) and covers better

Lime white (chalk)
Carbonate of lime
Gypsum
} (In oil tends to yellow). Little covering power.

Cadmium white.
Strontia "
Bismuth " blackens.
Tin " " dries badly.
Arsenic white
Antimony "
} Useless.

White lead has been so fully treated that it will be necessary only to refer to other parts of the book.

The best Kremser or Cremnitz is the best white lead for artists' use ; it is a very white and hard lead.

Zinc White is the only perfect white color, not being affected by sulphur gases and not yellowing the oil with which it is mixed. It is a slow drier and should get a little borate or sulphate of manganese as siccative. The Vieille Montagne zincs are the best. American ores contain sulphur, and their zincs sulphuric acid, which may become objectionable in mixture with lead. Zinc white undergoes a peculiar change by long keeping, by which it loses much of its covering power, which may, however, be restored by heating.

All methods of manufacturing zinc white are essentially the same, namely, the reduction of the zinc by heat to a vapor, in which condition it is changed by a current of air to flakes of zinc oxide. Some of the zinc particles may pass over with the zinc oxide unchanged, and particles of carbon from the fire may also become mixed with the zinc, both producing a gray color in the pigment. Zinc mixed with water tends to adhere in masses ; it should be thoroughly dried of water.

It does not so unite with the oil as lead, and does not at once so harden the soft not-drying oil acids. It does not, therefore, dry so quickly, nor make so hard or so bright a paint. It has some soap-making power, however, and after a long time gives a hard covering which takes a good polish, washes well and stands a long wear.

For adulterations of zinc white, see Chapter V. Cover and covering power should be observed. To test for whiting the oil must be removed and the zinc treated with muriatic acid, which will cause the whiting to effervesce.

It requires fourteen parts of oil to bring it into a condition of a marketable thick paste.

Other Whites (except the new Charlton White, etc., enamel white and other proprietary paints) are of little worth and so little used as to require no further attention than has already been given them. Some artists, however, recommend strontia white.

REDS.

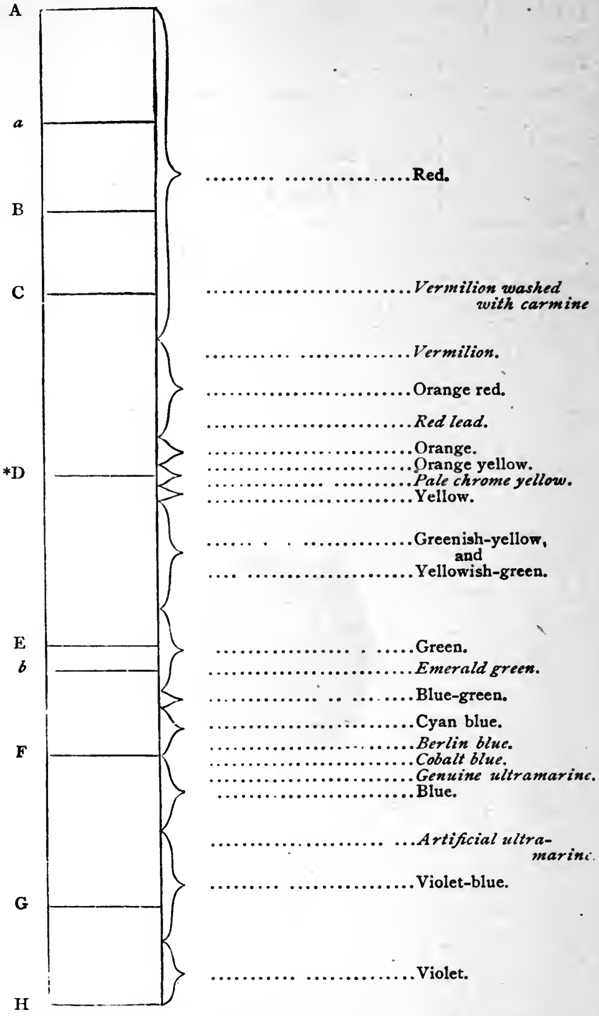
There is no pure red ; it is always mixed (excepting in the spectrum) with yellow and other colors.

Vermilion (English) is orange red ; red lead is still more orange. The red of the spectrum is best represented by carmine, or, in oil colors, by glazing with madder lake on a ground of cadmium yellow. After this color comes vermilion and then red lead, which shades into orange, which must be treated as a mixed color. *

***Von Bezold.**

	Stability of its kind.	Strength of tone
Carmine lake	Good.	Intense.
Crimson "	Less stable.	Weaker.
Scarlet "	Slight.	Adulterated with vermilion.
Purple lake	More durable.	
Florentine. Chinese	Like scarlet lake.	
Hamburg. Roman Venetian	Not stable.	Various.
Madder carmine lake	Excels in this respect.	Intense and transparent.
Rose carmine lake	Excellent.	Pure rose, no violet tint.
Pernambuco, Brazil wood, Vienna and Florentine.	Very poor.	Fair. Variable as manufactured.
Lac lake	Uncertain.	Not brilliant.
Chinese vermilion	Excels in this respect.	Carmine to purplish.
European vermilion,	Excellent.	Finer and yellowish.
Carmine vermilion	Excellent if pure.	Fiery.
Orange vermilion	"	Reddish, but mild.
Chrome red	Fair.	Good if in large crystals.
Cadmium red		Fine.
Vermilion (artificial)	As manufactured.	Good but harsh.
Red lead	Fair if alone.	Unpleasant.
Antimony red	Good.	Pure red.
Coal Tar Colors	Variable, useless, except under varnish.	Good, but too powerful.
Eosine dye	Somewhat durable under varnish.	Powerful.

Coraline..	Becomes yellow in oil.	
Ponceau..		
Fuchsine and Pernambuco wood lake	Powerful, but discolored by light.	
Mars colors,	Purer red, less yellowish than ochres.	
Indian red,		
Tuscan red,		
Vandyke red,		
Venetian red,		
Light red ochre	Excellent.	
Burnt (red) ochre	"	
Iron oxide	"	Dark violet to brown.



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*From Rood's " Chromatics " (D. Appleton & Co.), the position of the pig-

The diagram which precedes shows the *Fixed Lines ana Colored Spaces of the Normal Spectrum, the Position of the Colors, and of Some of the More Important Pigments.* The positions of the latter are not placed with the exactness of the other portions of the table.

Lakes.—A lake pigment is some white body, such as alum (or pure white alumina), starch, whiting or oxyhydrate of tin stained with a coloring matter, as that of the madder root, of the cochineal insect, dye-wood extract, aniline dye or the like. The white body thins the color and, becoming saturated, or perhaps chemically linked with it, produces a more lasting pigment than if the coloring matter were used alone. It does not and cannot, however, make the dye color perfectly stable, and therefore such lakes need a covering of varnish to protect them. An exception should, however, be made as regards the effect of alumina upon madder. Mulder says that cotton colored with madder is quickly bleached by the sun, but if the cotton is treated with acetic acid clay, and then dyed with madder, a lasting pigment is produced. Bouvier found madder lakes with alumina base the only durable ones. The amount of dye color on the white body is important, for on this much depends the lake's durability

Alumina lakes and tin lakes are especially durable; starch lakes are more transparent. Whiting (for

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ments was arranged by the writer of this book, out of materials furnished in the "Chromatics." In a prismatic spectrum, produced by passing light through a glass prism, one gets an incorrect idea of the relative amount of each color, as the red colors are crowded together and the violet colors stretched out by the prism. A *normal* spectrum is one showing the relative amount of space which should be occupied by each color; upon a diagram of a normal spectrum the exact shade of each pigment compared with a pure color can be better shown.

cheaper lakes) is the base commonly used; after it comes clay, then starch, and lastly tin, which is seldom employed. Different dyes require each a peculiar treatment and base.

Relation of the Base to Oils.—Alum is a pure clay, and it is probable that both alum bases and whiting (especially if wet with water) bases cause some of the difficulties which occasionally arise on the mixture of lakes and oil. Unless, as is the case of the carmine colors, the analine (tar) or the crystalline (Munich) madder colors, etc., the dye is very acid or very alkaline, the difficulty is to be laid to the base or white body of the lake.

Lakes used in carriage painting are more apt to chip and flake than mineral colors.

Madder Lakes.—Bouvier speaks of a Dutch madder lake in oil which had retained its color for 30 years,* but madder is adulterated with a variety of other coloring matters to get better color.

The red dyes made from madder (alizarine and purpurine) are the stable ones; the yellow dye (yellow madder lake) is less stable. Alizarine and purpurine have been produced from coal tar, but only a few foreign firms have as yet produced lakes from the artificial alizarine. The value of the lakes depends upon the amount of contained coloring matter, and this cannot be judged of by the appearance of the lake, because the base or body of the pigment will affect its covering power. The better method is to mix the lake with powdered chalk until a given shade is produced, and compare the amount of chalk neces-

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* Muckley says that the madders and the vermilions are the only reds in old paintings which have retained their original brilliancy.

sary to produce this shade with different varieties or samples of the lake. If one lake requires four parts of chalk and another six parts, then the value of the first to the second is as 4 is to 6 or as to 2 to 3.

Madder Carmine or Field's Carmine, says Mr. Slater, "is the richest and deepest lake prepared, containing the most coloring matter and least base * * * * * and is the only durable carmine for painting in water or oils."

It is expensive, more so according to the depth of color and the freedom from adulterations. It is apparently sometimes made with the addition of carmine when its durability is much decreased. It should be used with zinc white rather than with white lead.

Rose Madder is less permanent but gives a peculiarly soft carnation color, and gets admittance to the palettes of the most careful artists by its usefulness. It should be pure rose, not violet. Rose madder and probably all the madders cannot safely be used with flake white if *turpentine* be added. The dark, or *Munich* or *crystallized* lakes* are made by dissolving the prepared "krappkohle" (as the Germans call the prepared root) in a little caustic ammonia, which gives a thick, untransparent and dark-red fluid, from which are prepared lakes of various dark, beautiful and intense colors ; the intensity and darkness of the lakes being as the amount of the dissolved color stuff.

Munich Lake, says a practical painter of long experience, "leads the list for durability."

Chrome yellow, carmine lake and vermilion are all injurious to the stability of madder exposed to the light.

Change may take place in a few hours, if turpentine be added to a rose madder which has been adulterated with cochineal lake, especially if flake white be present. (Muckley.)

Purple Madder Lake or *Purple Rubinate* is, when true to name, an expensive pigment, soft and subdued and rich rather than brilliant.

Drying Qualities.—Madder lakes require about 62 per cent. of oils to bring them to a marketable paste; and all dry very slowly.

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* See also Carmine Lakes.

Robert's lake, *Laque Robert, Laque de guarance, Krap lac* are French and German names for madder lakes. The Robert's lakes are made by a process invented by a Frenchman of that name.

Test.—"If the liquid remain uncolored on adding ammonia to an assumed madder lake, in all probability the pigment is genuine."

Madder lakes are frequently adulterated with lakes formed from other cheaper coloring matters, and the violet lakes are sometimes found to contain Prussian blue. M. Chateau has devoted some attention to these adulterations. We quote his methods of detection as given in Malepeyres's treatise "On the Manufacture of Colors."

Red and Pink Lakes.—"These lakes do not color either hot or cold water. They color alcohol and ether very slightly, and only after a certain length of time. By calcination they leave a white residue of alumina.

"*Santaline.*—If the lake be dark it may contain santaline, which is detected by the *Orange-red* color acquired by the ether digested with the suspected lake. Alcohol, under these circumstances, would be colored *red.*

"*Brazil Lake.*—A madder lake, falsified with the lakes of Brazil wood, will be generally recognized by its effervescence with the acids, and its blue coloration by iodine. These reactions are due to the presence of chalk and starch, which are used for thickening the lakes made with Brazil wood.

"*Carmine Lake.*—Another adulteration of madder lakes is that with the so-called carmine lakes of an inferior quality. The fraud is easily detected.

"Water *is not colored* with madder, while it *is colored* with carmine lake. The coloration is immediate and becomes more intense by heating. This aqueous solution of carmine lake becomes *violet* by soluble alkalies, and gives a *violet* precipitate with lime water, chloride of tin, sulphate of copper, acetate of lead and sulphate of zinc.

"These lakes, under the action of hydrochloric acid, turn a dirty *orange yellow* color.

"*Campeachy Lakes.*—1. If adulterated with Campeachy lakes the addition of hydrochloric acid will produce a *crimson-red* coloration. After calcination the ash will be nankin-yellow or white, whether the Campeachy lake is partly or entirely substituted for that of the madder.

"*Alkanet.*—A madder lake adulterated by alkanet disengages violet fumes when heated. Moreover, such a lake is colored blue by alkalies, baryta and lime.

"*Prussian Blue.*—Prussian blue added to a violet madder lake for the purpose of deepening the hue is recognized by the addition of hydrochloric acid, which changes the violet of the lake to a green. Hypochlorites, and especially hypochlorous acid, turn the violet to a blue.

"*Black Lakes.*—By calcination these lakes give an ash of oxide of iron. Hydrochloric acid changes them by degrees into a dirty orange. They turn a brown, rusty color by the action of protochloride of tin.

"*Charcoal and Lamp Black.*—These lakes being of a fine black color, it is possible to falsify them with finely-ground charcoal or lamp black. This fraud will be detected by boiling the sample with hydrochloric acid, which will dissolve the lake, and will leave the charcoal or lamp black as a residue.

"*Black Campeachy Lakes.*—Black madder lakes may be mistaken for those of Campeachy. The latter will redden strongly by the action of hydrochloric acid and the protochloride of tin. In the first case the red portions will stain paper a cherry-red color, in the second case a more or less violet red.

"*Lake with Cochineal Basis.*—In order to distinguish a black madder lake from one with cochineal basis, an addition of chloride of tin will turn the cochineal lake a cherry-red, and white paper will be stained. The madder lake presents no such reaction.

Besides the vegetable coloring matters already named which serve to produce lakes, there are many others. The boughs of buckthorn and the berries of the elder give violet, red, chocolate and brown decoctions, the coloring matters of which can be combined with alumina, oxide of tin, magnesia, oxide of zinc and oxide of antimony. They are, however, of little value to the artist on account of their want of stability.

Red Wood Lakes.—From Pernambuco wood, Brazil wood, Japan wood (from Japan, Java, etc.), Nicaragua wood, African red wood, etc.

All the red wood lakes are of little value so far as stability is concerned, but vary as they contain more or less of the dye. *Rose Lakes* from Pernambuco wood, as they contain little coloring matter, soon bleach wholly white. Gentele says he has seen this occur in a room in a half-year where a madder lake was not the least changed.

Vienna red, Berlin red, new red, etc., are of the same class, but more stable, as they contain more coloring matter. Some of these lakes are in beautiful shades. The base is whiting, alum, starch or gypsum.

Spurious carmine lake, purple and violet lake are of the same character. All these lakes are in common use as water and oil colors. Lime changes them.

Their durability depends much upon the amount of contained color; and this may be tested by mixture with gypsum, as described above.

Carmine or Florentine Lakes—Are, if true to name, made from the cochineal insects, but there are so many imitations that the name is applied to any lake of carmine color. Carmine "No. 40" is a popular lake.

A variety known as "cochineal lake" contains no cochineal, but does contain arsenic, as resulted in several cases of poisoning.

Carmine is the principal component of cochineal, and in its purest condition is an intensely dazzling red powder, easily and completely dissolved in water or alcohol, and quickly decomposed by nitric acid, chlorine, bromine or iodine. Commercial carmine has only partially properties of the pure article.

Muckley says carmine and crimson lake will last half a century (?) if employed as a water color and excluded from the light; but if exposed, especially if combined with white lead, its color goes immediately.

Carmine bleaches quickly in the light, but less rapidly if shut off from the air ; all its lakes possess like qualities.

Bouvier found that, except the burnt carmine, none of these lakes would hold color more than a few months if exposed to the sun and air. The burnt carmine is of a rich purple tone and perfectly durable. Slater does not regard it as so durable.

The standard of stability for pigments is absolute unchangeableness. Changeable pigments are in constant use in all branches of finer painting, but the painter as well as the artist needs knowledge of the relative stability of each. Were that possible, we would give the average life of each pigment under various conditions.

They are injured by driers, by Indian yellow and possibly by vermilion, but on the *genuine* Florentine lake *sulphur gas has no effect.* Besides the genuine *Munich* lake, there is a *mixed* carmine and vermilion lake sold under this name. There are also mixed carmine and madder lakes, while carmine lakes from red woods abound. Where there is so much adulteration, detection is difficult. One great difference between madder colors and cochineal colors, on one side, and red wood colors on the other, is that the former are not affected by sulphureted hydrogen, while the latter, in solution, are uncolored by it. Carmine also differs from the colors of red woods, in the fact that these are not more beautiful at night, some changing under lamplight to a brownish hue, while true carmine is in all its shades less violet and more carmine red under lamplight. The following tests have value, especially the first :

"The lakes of cochineal may be known from those of the dyewoods by their solubility in ammonia, which purples but does not dissolve the colors produced by the latter." (Slater.)

"The carmine lakes are sometimes mixed with dye-wood lakes; in order to detect this adulteration the mixture is boiled with a little water, and a little iron perchloride is added; if the solution becomes of a dirty reddish-brown, it indicates the presence of the dye-wood coloring matter."

The Coal Tar Colors.—These have already been referred to. The red and violet dyes give quite as good pigments, both for appearance and durability, as many of the wood dye-stuffs. Sometimes both varieties of color stuffs are mixed. Aniline colors are also mixed on the same basis—that is in the same lake—with madder and with wood dyes.

Test.—Fuchsine is generally used for these purposes, and may be detected by washing the lake with alcohol. The lake if only colored by fuchsine will become colorless, and will be uncolored in proportion as it is colored thereby.

Adding caustic potash or soda to the red alcohol solution of fuchsine will change its color. Tar colors frequently (fuchsine especially) contain arsenic. They produce sores on the skin when much in contact with them. Children should wear old stockings under their bright new ones.

Vermilion Substitute.—Vermilion being a color in great demand, there have been, especially within the last few years, many attempts to find a substitute for it. There are a variety of these, but all of them are founded upon the analine colors and chrome red.

Chrome red (which may be used alone or with the dye) is chrome yellow in the condition of large crystals, and the smaller the crystals, the more the color tends toward orange; it will not, therefore, bear hard and long rubbing, as this breaks down the large crystals. It is, otherwise, less liable to change its color under light than is chrome yellow, but its tendency of change (by breaking up of crystals) is toward yellow.

It is composed of

Oxide of lead	81.1 parts.
Chromic acid	18.9 "
	100 "

and can therefore be easily blackened by sulphur gas, as the pure vermilion cannot be, although as the substitute vermilion is nearly always used under varnish, this is a less important matter.

In making the vermilion substitute it is not necessary to have a fine-colored (crystalline) quality of chrome, as the dye is relied upon for its color.

Unless the proper dye (eosine is serviceable) is used the color will become yellowish when mixed with oil. If properly made, however, and a sufficient quantity of the dye used, the color is fairly stable *under varnish*, as there is air as well as light needed to bleach out the color. Sickly red surfaces everywhere bear witness to the uselessness of aniline (tar) paints, except under varnish.

Chrome yellow is one of the most powerful of all the light reflectors, and the chrome red has some of its brightness, which adds to the fine color of the aniline dye.

The usual base for the vermilion substitute is, however, orange mineral. The *quantity* of the tar color is a very important factor as regards stability.

The tar colors are all affected by light and air, but shut up under varnish, they may yet afford the painter a variety of shades for indoor use. There is a great difference, however, in their stability. Anthracene blue, for instance, bleached in the sunlight with three times the rapidity of indigo. Some of the colors become yellow in oil in twenty-four hours

Eosine fuchsine, king's red and other tar colors are added to common vermilion and to chrome red, to fortify the color, and to chrome yellow to give a red color. Chrome red as color base may be known from vermilion by its large grains. From all of these substances thin soda or ammonia water solution removes the aniline color, which may be then thrown down from the fluid by the addition of some acid, as muriatic acid, which will produce a yellow precipitate. The color may also be washed from the vermilion by alcohol. In general, the painter will do well to test any aniline color first with oil, using a considerable quantity of color in order to find whether it bleaches or becomes yellow within four or five days (in darkness), after mixing with oil; second, by placing a thin wash of color in the direct sunlight to test its stability.

Vermilion.—Is composed about as follows :

Quicksilver	86.3	parts.
Sulphur	13.7	"
	100	"

Vermilion is sulphide of mercury (or quicksilver), which may be either red or black. If in a certain condition, as for instance in little crystals, it is red, otherwise it is black.

Little by little the rays of the sun change red particles of the quicksilver into black particles : the color of the vermilion is first darkened (black particles with the red particles), then changed to brown (more black particles), and finally to black sulphide of mercury. This change takes place more rapidly if the article has been made by the usual wet process. It takes place very rapidly if caustic potash, ammonia, or soda lie above it in a dish, when it acquires a bluish brown coat which, however, protects the color beneath from further change. These changes, however, are not chemical changes, but only changes in the form of the vermilion particles (molecular changes).

Vermilion made by what is called the wet process has the finest color and gives a larger amount of product for the raw material used, although it changes color under sunlight more rapidly.

Vermilion is blackened by sunlight, some lots are very quickly blackened; and where two kinds of vermilion have been used in the same pots on one job; or the vermilion has been carelessly and unevenly mixed or applied, black spots soon appearing, especially on those parts of the colored surface exposed to sunlight, may be caused by a change in the vermilion back to black sulphide of mercury. This change is a mere re-arrangement of the parts of the vermilion without gain or loss of substance; it is much like that taking place in sugar when dissolved; and this fact it is important to know, that the painter may not wander off into all sorts of vagaries in search of a cause for a change which is always, but gradually, taking place when vermilion is exposed to strong light.

By the dry process, sulphide of mercury, made by mixing sulphur and quicksilver, is partially changed into vapor by strong heat. On settling and by long rubbing, the black sulphide appears as red vermilion.

By the wet process, potash, water, sulphur and mercury are put together, and the mass changed to red vermilion by gentle heating. This process produces the finest colors, the dry process the most lasting.

The Chinese vermilion is the most durable as to color, but does not give the finest colors. Most English vermilions are also made by the dry process. The wet process probably gives the most uncertain product, the change from the black to red is easiest, and the change from red to black is likewise easy.

RULES FOR THE USE OF VERMILION.

1st. Do not mix two lots of the pigment, either in the paint pail or in a fresh condition on a painted surface.

2d. Stir up the paint from time to time while using it ; quicksilver is very heavy and settles from the oil.

3d. Avoid the use of driers containing lead. If blackening occurs, however, with the use of such driers, observe whether it takes place as a darkening of the surface or as a spotting with black in places exposed to the sun. If the latter you may be fairly sure that it has not been the lead, for there is good evidence that the lead cannot unlink the sulphur combined with the quicksilver, but only unite with the uncombined sulphur, *i. e.*, sulphur not linked with the quicksilver.

4th. Avoid the scarlet and choose the darker crimson vermilions for durability. The bright brilliant colors are less stable.

5th. Use venetian red as ground, and avoid contact of the vermilion with white lead.

As quicksilver vermilion contains sulphur (and often contains *free* sulphur) it is *possible* for quicksilver to be blackened by contact with lead, but it is also possible for it to be affected by long contact with zinc in powder.

Test for Purity.—Heated over an alcohol lamp, pure vermilion first turns black, the sulphur burns off with the blue flame and the pigment entirely disappears. If a sample so heated leaves a white precipitate it is probably adulterated with barytes ; if a black, it is probably adulterated with lead.

This, however, is no test for adulteration by sulphur.

Orange Vermilion is made from red vermilion ground very fine and washed with water until the hue is changed.

Vermilion dries very slowly, and as little oil as possible should be put with it. It should not be purchased in tubes, as it becomes tough.

Vermilion requires 25 per cent. of oil to form a marketable paste, then dry slowly.

Red Lead is composed of :

Lead	91 parts.
Oxygen	9 "
	100 "

Its color is more red as it contains more oxygen. It is of great value as a paint substance, but dangerous to use because it does not keep fluid in oil, and painters, mixing the fine powder with the oil, are liable to suffer thereby. It fades in mixture with white lead, and may become less orange alone in sunlight, but is more often whitened by the carbonic acid of the air, which changes it into white lead. It requires less oil than perhaps any other pigment.

Test is very difficult. The test usually recommended has no correct basis.

Antimony Red is in shade much like chrome red. It is a sulphide of antimony and has been proposed as a substitute for red lead—it would be an expensive substitute, but might be used in place of vermilion.

Antimony red may be know from chrome red by the fact that acetic acid changes the latter to yellow, but does not affect the antimony nor vermilion. It is a lustreless powder, but a lively red color in oil, excelling red lead and common vermilion. If well prepared, perhaps the purest red as an oil color, changing neither to orange nor carmine, but always with a slight tinge of brown; unchangeable in air and light it can readily be used in mixture with white lead. Has no effect in drying the oil.

It cannot be used with alkalies as it is slightly acid, and it is blackened by heat.

Antimony Orange is made by the addition of barytes to antimony red.

Iron Colors and Paints.—These may be natural or artificial. The trade distinctions, "mineral" and "metallic," have no very definite foundation, but are useful. The violet and brown shades are best for iron, because they contain little or no sulphuric acid. The bright red shades can be made only from sulphuric acid iron, and are themselves preservative of wood. Darkened and used with ochre colors, they form the best house paints.

There are clays colored with red iron oxide, and iron ores more or less impure with clay, etc. Of the cheaper sorts the so-called metallic paints are best for iron, but are too muddy and gloomy for wood unless mixed with the brighter colors, or with zinc white and blue. Moreover, the red sulphuric acid iron colors appear to have an "affinity" for wood. These last may be natural or artificial. The artificial are obtained by glow-heating in clay pipes sulphuric-acid-iron clay, or copperas. By one method various colors are obtained by adding common salt, and especially by proper periods of heating. Two per cent. of salt heated one hour, with gradual cooling, produces yellow; four per cent. of salt, *brown ;* six per cent. of salt and six hours of heat, *violet.*

Many shades of color, from yellow through red to purple, are produced, all having good covering properties. They are adapted to all uses, except painting iron.

These colors should be well washed after calcination.

The artificial colors are made from artificially prepared sulphate of iron, and from pyrites. The better sorts are pure or mixed with colors from natural sulphate of iron. The cheaper sorts are adulterated to price. For coloring, it is often better to pay four or five times the price of the cheaper article; for paints as protection the cheaper article serves if not too much adulterated. The names of the natural and the artificial colors have become badly mixed. Except the Mars colors, there is or has been a natural article for every iron color name.

Venetian red is artificial red iron oxide much diluted with gypsum, whiting and other substances. It is in various shades and grades.

Indian red is a pure artificial red iron oxide.

Indian red may be a natural iron ochre, and is inclined to darken—Muckley says it eats through white colors placed over it—by its effect on the oil.

Tuscan red is a pure artificial red iron oxide, tinted often, if not always, with red wood lake color; the color fairly stable, as the proportion of lake color is small. Tuscan reds give some of the most satisfactory car colors.

Vandyke red is artist color of artificial or natural sulphuric acid iron.

The Mars colors—yellow, orange, red, brown, violet, etc.—are also artificial oxides of iron, pure or combined with water, with alumina, or with zinc.

All iron colors are very stable, not being affected by air or light, although those less reddish violet have a tendency to lose oxygen and become blackened, apparently by formation of black oxide of iron. The adulterations, however, as well as some of the irons, often combine with the oil and discolor the paint to a slight degree.

The artificial colors are somewhat injurious to other pigments.

Burnt Ochres, Light Red, etc.—These have been referred to on page 43. Their color is more yellowish and brownish than artificial iron colors. They are very stable.

Brown Red is made by heating to less than melting heat one part of iron oxide and ten parts of red lead, rubbing the brown mass so produced.

YELLOW.

Yellow is the brightest color of the spectrum; brightness is the peculiar quality of yellow—toned yellow appears brown, as may be observed from the folds in yellow drapery. Brown strongly illuminated appears yellow.

	Quality of color.	Effect of impure air.
American chrome yellow	Brilliant but harsh.	To blacken.
Pale chrome yellow		
Sulphur-colored chrome yellow		
Orange chrome yellow		
Dark citron yellow		
Cologne yellow		
Yellow mineral		
Baryta yellow or lemon yellow	Pale with little force, but clear.	No effect.
Zinc yellow or yellow ultramarine	Much weaker than chrome yellow.	" "
Strontian yellow	Pure yellow.	" "
Mars yellow		" "
Aureolin	Beautiful.	" "
Cadmium yellow deep	Brilliant and softer than chrome yellow.	" "
" " pale		
" " lemon		
Naples yellow	Variable but good.	Blackens very much.
Raw sienna	Impure yellow.	No effect.
Yellow ochre	Bright, pure but not brilliant.	"
Yellow ochres, dark	Reddish or greenish.	"
Indian yellow	Pure.	"
Yellow lake	Transparent.	"
Dutch pink	"	As made.
Pure quercitron lake	"	

None of the last four colors are permanent. The Indian yellow is made from the phosphate of lime soil of camel stables. The quercitron is affected by lead in oils or varnish—that is, it is discolored. Dutch pink is of a variable character as manufactured, but seldom stable. The Indian yellow is fugitive in oil, although stable as water color, and injures carmine lake as mixture, probably because of its ammoniacal character. No yellow lake has much endurance. Quercitron may be known by its relation to lamp light, as it does not, like other yellows, appear less brilliant.

Yellow lake is usually made of Persian berries on an alumina base. It is not stable, and if quercitron is added it may be affected by lead.

The stable yellows are Naples yellow protected from impure air and contact with iron, the deeper cadmiums, and the best lemon yellow (?). The stable orange pigments are cadmium orange, orange vermilion and, for russet-orange, burnt terra di Sienna.

Chrome Yellow is a powerful light reflector—it has four times the brightness of Naples yellow.

A. Dark citron chrome yellow is

Lead oxide	68.2	parts
Chromic acid	31.8	"
	100	"

B. Sulphur yellow chrome yellow is

Red oxide	70.9	parts
Chromic acid	16.5	"
Sulphuric acid	12.6	"
	100	"

C. Pure red chrome yellow is

Lead oxide	80.1	parts
Chromic acid	18.9	"
	100	"

The last is red because it is in the form of crystals, and is much the same as the *red lead ore* of Siberia, in which the substance chrome was first discovered. When its crystals are small or become broken, lead chrome becomes yellow.

From *A*, *B* and *C* can be made up the various shades of chrome yellow; they are also produced immediately and in a variety of ways. The color is valuable, however, as it contains chromic acid lead, and the amount of coloring matter varies greatly as the pigment is greatly diluted with barytes, gypsum and other substances. The best dilutant is barytes.

Test.—Chrome yellow is most easily tested by mixture with zinc white, and comparing with a standard sample mixed in the same manner and proportions, the comparative strength of the produced tone determining the value of the article; or test may be made by comparative mixture with Paris blue to produce a given shade of green. The covering power of chrome yellow is great, and no sure test can be made merely by application of the paint to a surface. It is necessary to have a pure chrome yellow for exact comparison, but comparison of relative value may be made between samples. Rub one part of the chrome yellow with ⅓ part of Paris blue, and in proportion as the produced color is yellowish there is more yellow color in the sample; in proportion as it is bluish, there is less. The more of the chrome yellow sample it is necessary to use to match the test sample, the weaker is the color with chrome yellow. It is, of course, necessary to compare dark shades with dark shades, and light shades with light shades; but orange shades must be simply mixed with barytes in order to a fair test, and not with Paris blue; or they may be gauged directly by their covering power on a surface. The following is an analysis of an American sample of chrome yellow analyzed by Debruner :

Moisture	0.15	parts.
Barytes	47.00	"
Sulphate of lead	7.+	"
Total adulteration	54.5	"
Chromate of lead	45.+	"
	100	"

The danger to chrome yellow is always by the blackening of the lead by sulphur gases (and probably some reduction by light rays), and for this reason it has been rejected by many artist painters. It should not be mixed with any lake, as it is injurious to all organic colors in the sunlight, but is itself not much affected by sunlight. A fresh lime wall reddens it.

Chrome greens are nearly without exception mixtures of chrome yellow and Prussian blue, both diluted with barytes, etc.

Chrome yellow requires little oil to bring it to a marketable paste (19 per cent.), and dries as quickly as red lead.

Cologne Yellow is a very inferior chrome yellow containing lime and sulphate of lead.

Zinc Yellow, or Yellow Ultramarine, Chromate of Zinc, etc.—This pigment is produced in a variety of ways; among these coloring zinc white by some yellow dye stuff, when the color will not be durable.

Test.—Zinc yellow may be know from chrome yellow by the fact that it is partially dissolved in water, and that when free of barytes it is completely dissolved in muriatic acid. Its one advantage is that it does not blacken by sulphur gas, as does chrome yellow. The true chromic acid zincs may be known from a dyed zinc white by the fact that when dissolved in muriatic acid the solution becomes green on the addition of alcohol—indicating the presence of a green chromic acid salt made from the chrome with the zinc.

Its tendency of change is toward green by separation of chromic acid, and it is therefore somewhat injurious to organic colors.

There is a tar color on a clay-zinc base which has beauty and intensity, great covering power as a water color, but less as oil color (is transparent). It gives beautiful shades of green.

An American zinc chrome yellow.

Chromic acid	34.06	parts.
Zinc oxide	36.41	"
Potash	13.79	"
Sulphuric acid	11.58	"
Water	4.68	"
	100+	parts.

It was evidently a zinc chromate with a mixture of sulphate of potassium. (Allen.)

Cadmium Yellow is an expensive, but, when pure, beautiful, brilliant and durable yellow not blackened by light nor by impure gases. As regards light, this is perhaps true only of the darker (orange) cadmiums. It is:

Cadmium	77.71	parts.
Sulphur	22.29	"
	100	parts.

The lighter shades, however, contain zinc in proportion as they are pale; the darker sorts are sometimes may by glow-heating; the lighter by a "wet" or precipitation process, and there may be a difference in the resulting pigment aside from the mixture of zinc. The lighter sorts, especially, have been thought to be adulterated, and the temptation to adulteration is, of course, in proportion to price; but the question also arises as involves price, whether the amount of color sold would be sufficient to tempt any respectable dealer to adulterate this or any other artistic pigment.

More probable is it that the fading of pigments arises not from adulteration, but from other causes—improper manufacture or improper use. The well-known artist, Holman Hunt, uses the fuller (darker), but carefully rejects the pale varieties. It should be used with zinc white rather than with white lead.

Cadmium yellow is made darker when shut out from the light, but the color is heightened by sunlight. It must not be mixed with copper.

There is a chromic acid cadmium oxide, but it is very expensive.

It has great covering power.

Test.—It is completely dissolved by strong muriatic acid, leaving adulterations as precipitates.

Lemon Yellow, Barytes Yellow, Chromic-acid—Baryta.—This pigment is of a pale yellow color, of little power, but of great durability against light and bad air ; and is an exceedingly difficult one to manufacture in fine quality, and as made *doubtful.*

"If properly and carefully prepared, it is of a vivid lemon tint, deep or pale and very clear," it produces permanent greens with blue. It has been accused of turning greenish in the light—but this is not at all probable.

Muckley says, after repeated tests, he finds modern *lemon yellow change very rapidly*, and that it is usually a chromate of strontia.

Strontian yellow should be a chromic acid stronthia, which is slightly soluble in water, and in other respects like zinc yellow. The common strontian yellow is said to be mixed pigment. Hamerton places it with the most stable colors, but about its stability there must be great doubt.

Aureolin is a comparatively recent and expensive pigment, fairly stable, not affected by light or impure air. It is composed of nitric acid + oxide of cobalt + potassium.

Test.—Place a little of the pigment and sulphuric acid in a porcelain dish, and evaporate the acid over an alcohol lamp. The pigment will give off much nitrous vapor and remain as a red precipitate, which will dissolve in and color water red. This solution in water will be complete if the pigment contains no barytes or lead.

We warn the reader that tests by chemical reagents are very unsatisfactory unless made with the aid of a person accustomed to chemical manipulation. *The use and keeping of acids also involve some danger.* A good pharmaceutist should be able to make satisfactory chemical tests.

The strongest praise has been given to this color, but as Hamerton says, "It is delightful to work with, but too recent to know thoroughly well as to stability." Some artists report unfavorably as to its stability. It is valuable, as it does not affect lead colors. The exact chemical relations of its constituents are not known.

Naples Yellow.—This pigment is a variable compound of antimony (antimonic anhydride) and lead oxide which has great stability in light but is changed by impure air and quickly blackened (the antimony) by the least touch of iron. Its yellow always varies in color, and is paler as a dry pigment than when mixed with oil or even with lime color. It is one of the most durable of all yellows, if properly protected, and with blue gives durable greens.

Naples yellow *as now sold*, as an artist pigment is, says Muckley, "a combination of deep cadmium and white lead."

Some American houses, at least, sell the *genuine* article. F. W. Devoe & Co. have nine shades—orange to green.

Unnecessary use of this color should be avoided because of its poisonous character. For like reasons, also, we omit full mention of all colors containing arsenic. Hamerton recommends as a substitute for Naples yellow a mixture of stronthian white and yellow ochre. It (if genuine) *must not be used with ochres nor in any way come in contact with iron.*

Ochres.—Hydrated oxide of iron (*i. e.*, iron rust containing water) is of a strong yellow or brown yellow color, becoming more of a pure Nankeen yellow as it is mixed with a pure white substance.

All yellow and brown-yellow ochres, gold ochre, bronze ochre (having a shade of green), etc., known by various names, have their yellow color chiefly from hydrated oxide of iron and are so much the darker the more they contain it; although part of their brown color comes from hydrated manganese oxide, of which ochres contain a little. The covering power of the ochre depends in large measure upon whether it contains lime or chalk, which, making it more translucent, reduces its coloring power. Ochres are found in all countries, but the most celebrated and those chiefly used in painting come from France, differing in price according to their purity, the fineness of their powder and the care with which they have been washed. The hydrated oxide of iron loses its water by heating and becomes red and more and more brownish and violet the stronger and longer the heating; the darker colors contain more manganese and are therefore better driers.

There are fine (carefully washed) Paris ochres, and the English Oxford and stone ochres are among the best. The Roman ochre grades with the best Havre ochres; the lower grades of French ochres are poor and perhaps to be placed lower than the best Bermuda (Virginia) ochres.

Drying Qualities.—Ochres require from 60 to 80 per cent. of oil to make a marketable paste, and are consequently poor driers.

Adulterations.—Aside from excessive amounts of clay, which soak up the oil, ochres are injured, as we have said, as they contain lime orchalk. They are also adulterated (aside from these natural dilutions) with barytes. Tests may be made comparatively as to their color and covering power by mixture with white lead, and as to their quality by the amount of oil required to bring them to a paste.

Stability.—Ochres are the most stable of yellow colors, although the light yellow will blacken a little in time, possibly by the effects of sunlight, possibly by changes in the oil. Dark yellow ochre, gold ochre, Roman ochre, Oxford ochre, stone ochre, brown ochre, or ochre de Ru; the most brilliant is the gold ochre; the ochre du rue is milder, and the stone ochre a little greenish; all these darken somewhat, the gold ochre always,* the stone ochre less than others.

These ochres, with Berlin blue, give good greens.

Yellow Madder is of a brownish yellow hue, rich and transparent; used as a glazing color.

Mineral Yellow, Turner's Yellow, etc., is a discarded lead-pigment, made from red lead and common salt (chloride of sodium).

King's Yellow, Chinese Yellow, Ocpigment is highly poisonous.

Mars Yellow is an hydrated oxide of iron, which in thin layers is yellow and in thick layers brownish, and more pure yellow if combined with zinc.

It is an artificial iron yellow, made with sulphate of zinc and sulphate of iron. It is also prepared from sulphate of iron and sulphate of aluminium. It is frequently adulterated by yellow lead, which is blackened by impure air.

Iron Yellow is often a dark shade of chrome yellow.

Mosaic Gold, or sulphuric acid tin, has the advantage of not blackening in impure air, as does metallic bronze. The mosaic gold is a pure gold or brownish yellow in lustrous mica-like scales, easily wounding the skin when touched; insoluble in water. A

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* As this ochre dries more quickly than others, and contains lime, part of the darkening is due to the oil.

cheaper gold is made from four parts of tin foil, three parts sulphur, and two parts sal-ammoniac heated in a sand bath for several hours.

Gamboge is a resin which is not stable in oil, but valuable as water color. The lump gamboge gives with water an emulsion which iodine tincture changes to dark green. With chalk, gamboge gives a yellow color; with iron a beautiful brown, both of which can be used as fine wall color.

Used as a glaze, it protects other colors.

Litharge.—The color of the litharge is obtained by slower or more rapid cooling, the latter giving a more yellow, the former a redder color. Gold litharge is made by pouring melted litharge into an iron vessel, and then breaking the crust as soon as formed, allowing the fluid lead below to flow over the surface. *Orange mineral* is a litharge made from refuse white lead.

Litharge means "silver-stone," a name given to it probably by the old alchemists because they obtained so much silver from it. It is still made of lead which contains so much silver as to be useless for making white lead, or it is made from refuse white lead (massicot and orange mineral especially).

When lead is heated in the air, it takes up oxygen, and becomes first yellow, then red. One hundred parts of lead take up about 4 parts by weight of oxygen, and become litharge.

BLUE.

Genuine ultramarine, the most expensive of all pigments, approaches more nearly to a true blue, as may be seen by the diagram on page 306.

Berlin blue tends to green, cobalt blue much less so. While artificial ultramarine goes toward violet, genuine ultramarine by its light and qualities approaches nearest to pure blue, cobalt following closely after. In their best state, however, all these pigments are true blues (but, excepting the one, all have tendencies to change), blue being a color of a variety of shades and qualities in a peculiar sense.

LAPIS LAZULI.

Native Ultramarine.—"This most beautiful of all blue pigments is obtained from *lapis lazuli*, a mineral of somewhat rare occurrence. The finest samples of the mineral are obtained from Prussia, China and Great Bucharia. It is usually an earthy bluish-gray tone, enlivened with pure azure and deep blue. It contains not unfrequently small glittering crystals of iron pyrites, which at first gave rise to the idea that the blue color was in some way due to the presence of iron. It is now, however, well ascertained that such is not the fact. To procure the blue pigment free from the earthy matters with which it is intimately mixed, it is first necessary to reduce the mineral to a fine powder. This is greatly facilitated by heating the substance and cooling it by immersion in water or vinegar. It is then ground in a mill. The powder is mixed with a pasty composition prepared with resin, wax and linseed oil. This mass is placed in a cloth and kneaded under hot water. The first portions of coloring matter expressed are generally dirty; but as the operation proceeds, the brighter portions make their way through the cloth. Inferior qualities succeed. These are carefully collected and classified. This operation is tedious, but hitherto no better method has been suggested. It would seem that the ultramarine adheres less to the composition than the gray earthy matter with which it is associated. This pigment is very expensive, owing not merely to the rarity of the mineral, but also to the labor required in its preparation. For purity of tone and stability it has no rival.

For a long time the composition of this body remained a mystery to chemists. The analyses did not give any clue to the nature of the coloring matter. Chemists were stimulated by prizes to find a method of preparing the pigment artificially; after long investigation perseverance was rewarded and an *artificial ultramarine* was produced, which if not equal to the native body in purity of tone, is but little removed from it. It would appear that a memoir, published by Gmelin in 1828, gave the key to its ready production. In fact, that chemist gave a formula for manfacturing it which has only been varied in minor details by the best makers of the present day."

The finer color comes from the deeper portions of the stone. It is a good drier.

Test.—The natural ultramarine holds its color well in acetic acid and alum solution, while these destroy (more or less quickly) the color of the artificial, with development of sulphureted hydrogen odor.

Artificial Ultramarine (French ultramarine, etc.)—An enumeration of the raw materials used in making ultramarine will aid in the comprehension of the substance as a chemical product and pigment.

1. Clay (silicate of aluminum) or other white clay-like compound.
2. Sulphuric acid soda.
3. Carbonic acid soda.
4. Refined sulphur.
5. Quartz sand (silicic acid).
6. Coal or charcoal.

These materials, properly prepared, are heated, and produce a yellowish-green to greenish substance, which is made up about as follows:

Silicate of alumina (clay)	47.31	parts.
" " iron	1.95	"
" " soda	39.93	"
Sulphur	6.62	"
Soda	3.92	"
Potash	1.13	"
	100.86	parts.

This is green ultramarine, which at its best is a bluish green, becoming a dull greenish blue on exposure. The green ultramarine is again roasted, with the addition of sulphur in some form (as gas commonly) and becomes blue ultramarine apparently (as Dr. Rollner was the first to suggest), because the pure sulphur covers the surface not of the gross pieces of pigment, but of its little molecules (molecules of the silicate compounds). Gold is yellow, but in solution it becomes blue, and it is thought that the finely divided sulphur may, by reflection of the light through it, give the blue color. This is practically a valuable theory, as we shall see.

Ultramarine in large grains has less of the blue but more of the green or else of the red color. In comparing the value of two samples it is necessary to rub them to an equal fineness; their comparative color and coloring power may then be tested by mixture with gypsum.

That color which requires most white to bring it to a standard shade, or which, mixed with a given quantity of white, produces the deepest blue, is the more valuable. Ultramarines are of various prices, some costing five or ten times as much as others, according to the care and materials used in manufacture—but purity of color does not necessarily correspond in all cases with price. In fact, different makers produce varying shades of various fineness of grain. Those sorts ground wet are dearer; those sorts containing gypsum cheaper.

Test.—When weak muriatic acid is added to ultramarine there is a loosening of sulphur gas with the smell of bad eggs. No other color will give this odor, but as further test a paper, or white cloth, dipped in the ultramarine and placed in a glass containing a little muriatic acid with considerable water.

Over this glass is placed a paper wet with sugar of lead and touched with a little ammonia. If the ultramarine be genuine, the lead will become blackened by the sulphur gas and the blue color of the cloth or paper will disappear.

A second method is one which may be used to test any blue color.

The blue powder is treated with strong sulphuric acid—**(poison).**

BLEACHES.	NOT BLEACHED.					
	The fluid remains blue. Dilute with water.			The fluid becomes brownish red. Dilute with water.		
	Bleaches with odor of sulphureted hydrogengas.	Not bleached.		The color stuff separates in wine-red flakes.	The blue color returns.	The fluid is green.
		The blue was already dissolved or becomes dissolved.	The blue is completely *un*dissolved.			
Berlin blue.	Ultramarine blue.	Indigo.	Smalt.	Anthracene or Alizarine blue.	Aniline blue.	Methyl blue.

Of the above, alcohol dissolves only the aniline and the methyl blue. Indigo-carmine remains quite undissolved in very pure alcohol, but caustic soda solution changes it to yellow [the anthracene blue (dissolved in water) to green, and bleaches the Berlin blue]. The original (indigo) blue again appears on neutralizing the mixture with acids.

Anthracene blue comes as a brown powder, having a copperish lustre, and it easily dissolves in sulphuric acid. Raw indigo dissolves completely in the water and sulphuric acid only after sufficient time has been allowed for the acid to take effect.

Stability.—Ultramarine is very stable as against light and impure air, but not against acids which destroy even the natural lapis lazuli. It is sensitive to damp air even in oil (see page 242), and may take up as much as 5 per cent. of moisture in its dry state. The white lead mixture may blacken. Ultramarine does better with zinc white. Its tendency of change is either toward violet or toward gray, not toward green, with some tendency to blacken by causes which act in time.

Varieties.—There is a brilliant ultramarine and a violet, besides the more common sorts.

Cobalt Blue.—Cobalt is a metal found in combination with arsenic, iron, nickel, etc., etc. Arsenic is necessary to the production of a well-colored smalt, as it prevents the injurious action of other substances which are found in the cobalt earth. Smalt contains considerable arsenic, and should therefore be used with care.

Smalt is a cobalt glass, very lasting, and specially valuable as water and *wall* color. It is sometimes used as a powder on other blue oil paints. It is frequently used as a drier, its drying properties being contained free alkalies, which exist in all cobalt glasses. These make a soap with the oil, and probably in unwashed smalt color caused some of those changes of which Salter complains. If the smalt is to be used as a drier, it should not be washed. Bouvier complains of its powdery nature when too little oil is given it, and says that its drying properties are so great white color with it cannot be kept longer than four or five days. It should be made with a potash glass, as soda in the glass produces a reddish or brownish color. If the ore contain nickel, the smalt has a violet tone. It is sometimes adulterated with chalk.

There are so-called smalts which may be merely colored silicates, from which turpentine will wash the color.

Cobalt Blue, Thenard's Blue.—Properly prepared is one of the purest and most stable of pigments and one of the more expensive. If made with pure clay, it has a reddish shade, but with zinc added the color is pure blue, and with more zinc, greenish blue. The depth of the color depends upon the amount of the contained cobalt oxide.

If made with precipitated clay, glow-heated with nitric acid (or phosphoric acid) cobalt, it is very expensive and Thenard's blue is not always so prepared, as there are different methods. Phosphoric acid cobalt is a beautiful color, much used in porcelain painting. It dries less rapidly than smalt and requires for a marketable paste 125 parts of oil.

It has a purple tone by lamplight.

Cerulean Blue or Coeruleum Celestial Blue is a stannic (tin) acid cobalt. It is sky-blue and retains its blue color by lamplight, but is slightly greenish by daylight. Its tendency of change is toward green, but it is a stable color.

Cyanine Blue is a compound of cobalt and Prussian blue, agreeable, but hardly more durable than Antwerp and Prussian blue.

Prussian Blue and Paris Blue.—This very useful pigment is very durable, but as will be shown, (see Sunlight and Pigments) it is greened or bleached by sunlight, the bleaching being more apparent as the pigment contains less Paris blue. It is blackened by sulphur gases and impure air, and destroyed by all alkalies, as for example, lime. It may be mixed with somewhat acid pigments, but not with any which have not been completely washed of carbonic-acid alkalies or caustic alkalies. With pure yellow, it gives a pure green, shaded by the quality of the yellow. It fades more easily in such mixture (chrome yellow and chrome zinc, white lead, etc.), but is more durable in oil than as unprotected color. It differs considerably in color, depth and permanence, according to the materials used in its manufacture as well as by the amount of its dilution with barytes, clay, starch, etc. *Berlin blue*, *Hamburg blue*, *new blue*, *Antwerp blue*, etc., are diluted Paris blues.

If the addition (dilution) is barytes the Berlin blue, etc., will in mass be heavier ; if it is lighter in weight and has not a smooth fracture surface, it is starch ; if the fracture is like that of broken earth, it is clay ; if the mass be hard with a rough fracture surface, the addition is gypsum.

Test.—In oil, Paris blue is a very dark, almost black blue, and Berlin, Hamburg and other blues vary in color somewhat (but not proportionately) as they contain more white substance and less of the blue color. Difference in the addition (dilutant) produces a difference in the appearance of the pigment, and to test the amount of blue present, it must be mixed with white lead or chrome yellow. Two grains of a known blue rubbed in oil with twenty grains of white lead will give a standard color. Taking two grains of the color to be tested, white lead should be added until the shade matches the standard shade; if less than twenty grains of white lead are needed to match the standard, the blue is better; if more, the blue is weaker than the other, or test blue. In the same way the blue may be tested by mixture with chrome yellow to form a green. The least blue pigment required to form a given shade of green with the same chrome color, the more valuable it is as having greater covering power. (*See also Ultramarine Tests.*)

Berlin blue requires 112 parts of oil to bring it to a marketable paste, and diluted with barytes needs a drier. *Prussian or Paris blue* differs considerably in depth and permanence, according to the materials used in its manufacture as well as the amount of its dilution. A good unadulterated sample in the dry state is intense blue, almost black, hard, brittle, and much like indigo, with a copperish red fracture. When carefully heated, it gives off water and takes a pale green hue.

Prussian blue, not durable; in water color, when exposed to light, it soon fades. The works of the old early water-color painters of this century bear sad testimony to this fact. The faded condition of some of the works of Copling, Varley, Virtin, Prout, Cox, Turner and others are chiefly the result of indigo and Prussian blue. Antwerp blue is less stable than Prussian blue. (Muckley).

Newburg Blue is a mixture of copper blue with Paris blue, and is darker, as it contains more of the latter. It is a good oil color, but affected by lime and iron.

Night Blue gives the same shade by lamplight as by sunlight, and is made from equal parts of Berlin blue and indigo-carmine. It is injured by a heat above 176 degrees.

Turnbull's Blue may be made from Paris blue; but otherwise produced (as is the genuine article), it has not the strong, copperish lustre of Paris blue, and is lighter and of a more delicate color. It is thought by some to stand better than Paris blue.

Indigo is a vegetable dye-stuff obtained as a colorless liquid from the leaves and stalk of indigo plants (*indigo ferae*).

The leaves are treated in several ways: a common method is to steep them in a vat; when the fluid extracted from them, which is at first colorless then slightly yellow, becomes green, it is beaten with wooden ladles until it changes to a light blue, and finally to a dark blue. Artificial indigo has also been made from tar, but is little used as yet.

Indigo contains a number of dyes, but indigotine alone can be used for dyeing blue. It it is a curious substance as regards color, and may be either (a) colorless, (b) violet or (c) blue.

Indigo blue is not soluble and is changed by the action of alkali into the white indigo, which is soluble, and which becomes changed again into blue color by the action of the air—removing some of its hydrogen.

Indigo Carmine.—Indigo is made by the action of sulphuric acid and heat upon indigo; and is soluble in water and of a copperish lustre, and by its solubility in water it may be known in mixtures. Indigo is used to some extent in painting, and has less stability than Paris blue, and has a tendency to soak a porous surface with color.

Test.—Held against the light, indigo carmine painted on glass gives a pure blue color—no green, but a tinge of violet.

Intense Blue is a strong indigo blue.

Copper Blues.—These are natural and artificial. The natural mineral blue is composed about as follows :

Oxide of copper	69.37	parts
Carbonic acid	25.43	"
Water (H. O.)	5.20	"
	100	"

It is a fiery powder with little covering power as a paint. It is chiefly used as a water color, and approaches the sky-blue of the cobalt color. It is not permanent, and is blackened by sulphur gases.

Test.—It is dissolved by strong ammonia, which, however, will leave undissolved any chalk which may be mixed with it.

Bice, Blue Ashes and Saunder's Blue (*Cendres blue*) are natural or manufactured blues ; they may be either, but are usually the latter. There is also, in addition to these, a natural blue ochre or phosphate of iron. There are also manufactured copper blues, with various names; and among these zinc-white colored with Berlin blue, which sometimes bears a copper blue name. The true artificial (copper) blues are valuable chiefly as wall colors, not being changed by lime. In oil, they become greenish.

The copper blues made with the addition of Prussian blue cannot, however, be used with lime. They have, however, more covering power than the pure copper blues, which cover but little in oil, as they are more or less in crystals (see page 35).

Bremer Blue and Lime Blue.—These are chiefly wall paints; the first for oil, water and lime color, the second for lime alone. Bremer blue is an hydrated oxide of copper, of a greenish blue color, which in oil with age becomes yet more green. It is not affected by light, but the moisture of walls greens it and it is more easily blackened by sulphur gases than even white lead. Lime blue has much the same qualities as Bremer blue, but has very little covering power mixed with oil, and, like it, is blackened by sulphur gas; it is valuable, however, as not being affected by lime.

Manganese Blue is a combination by glow-heating of manganese, quartz and chalk. Manganese gives depth of color, more of the quartz gives the greenish cast. All manganese compounds suffer by contact with organic substances, and it is therefore not very stable in oil or mixture.

GREEN.

Green is nature's most every-day color, but not pure green. The green of nature is largely red; indeed, grass is redder than a red brick. There is no pigment which will represent its color, and the fact is a warning to all who use green to redden it, keeping it, nevertheless, well away from yellow—the green of which is the most sickly of all hues. In decoration, green is a most difficult color to hit, unless as a tone to brown, yellowish or gray, when the green loses much of its distinctive quality. It is, nevertheless, rapidly becoming the decorative color of art. As such, it is all-important that it should be represented in pigments having no poisonous qualities, or at least, without poisons which can infect the air of rooms as will arsenic. Green, the pure green of the spectrum, is perhaps more nearly represented by the emerald arsenic green than by any other ; but there is also in the spectrum a color represented by "yellowish-green vermilion," on one side, and verdigris (in its older and deeper shades) on the other.

Viridian Guignet's Green, *Vert Pelletier*, *Vert Virginal.*—This is a poison-free color of a dark, fiery green, which cannot be equaled by any mixture of blues and yellows. Placed with a fiery yellow it gives a pure, beautiful color, which approaches very near the Paris green at its best.

Guignet's Green is an hydrated chrome oxide made with the use of boracic acid and heat. It is a very powerful green, permanent except as regards heat, which drives off its contained water and changes its color. It completely withstands both light and impure air. As painter's color, in its pure condition, it has small value, being crystallized, but mixed with permanent white (artificial barytes) it covers much better, although with a change by the mixture to a grayish-blue color.

Victoria Green and Permanent Green are some times, if not always, varieties of Guignet's green.

Test.—Melted in a porcelain vessel with saltpetre, these, like other chrome oxides, change to chromate of potash.

Genuine Chrome Greens (Sesqui-oxide of chromium) are very durable, but somewhat grayish greens, mostly used in porcelain decoration.

Elsner's Green is a bluish green made from yellow wood dyes and copper vitriol ; a very fair green which darkens somewhat in oil.

Tin Copper (stannate of copper) *green*, has the advantage of possessing always the same shade. It rivals the arsenic greens in richness and should, perhaps, replace them in many cases.

Green Smalt (Cobalt green, Rinman's green) is made by glow-heating zinc white with a small quantity of cobalt salts. The more contained zinc, the brighter the color, which may be produced in many shades. It is the cheapest cobalt pigment, which, however, Mr. Salter says, has little favor with artists, because of its transparency and character of the green.

Gellert's Green is much the same as that of Rinman.

Turk's Green (which is an oxide of chrome + quartz + oxide of cobalt) is also a lasting bluish green, but more expensive and less brilliant than Guignet, but unchanged in color by lamplight.

Green Earth, *Terre Vert* (Ochres), etc.—Veronese, the best ; it is the color of verdigris and is solid. Cypress earth is more of an apple green, and is softer. The Bohemian earth has a handsome green color and comes in a solid compact mass. Poland earth is more of a green leek color and is frequently mixed with sand. Tyrolese earth is dull green, but sometimes approaches in color the Veronese. Green earths when properly washed and dried are desirable colors, but have no beauty or lustre, they resist atmospheric influences fairly well, but darken in time; they are also often treated with muriatic acid to give them fire, as by this means foreign matters are dissolved. They become, when strongly roasted, brown red.

Veronese Green, which is made up of silicate of iron and clay, is known also as Stone green, Mountain green, Malachite green; these are made of the smaller pieces of malachite ground and washed. First grade is the pure mountain green. Second, the ochres, under which are three classes: (a) Malachite, (b) oil color, (c) ground color. Alexander and Napoleon are shades of mountain green, besides these a green ochre or verditer. This is a so-called green earth; it is quite useless in oil, as it blackens. There is an artificial French Veronese green which often contains arsenic. Veronese greens, says Muckley, have a tendency to attack other colors combined with them.

It will be seen from above that a poison free, but perfect, green is still wanted both for artistic decoration and common use.

Verdigris is the rust of copper by acetic acid (grape vinegar), and may be raw or distilled (crystallized). It may be blue or green. Verdigris and white lead produce a very lasting paint, which is first bluish, but becomes brighter green with age; much used in Russia for roofs. By the mixture carbonic acid copper and acetic acid lead are formed, both of which unite with the oil as soap.

Verdigris becomes first yellowish and then quite dark in oil. It may, however, be used as a glaze rubbed in copaiba balsam and used with a little mastic varnish ; but this mixture dries very quickly under the brush, and must be mixed in small quantities. In carriage work verdigris may be used as a glaze, in varnish or japan, in very thin coats.

Those exposed to powder of verdigris should drink a glass of very sweet water or molasses, which is an antidote.

Arsenic Greens.—The poisonous copper greens are numerous, the most beautiful being, perhaps the emerald green and the best Sweinfurth or (as diluted) Paris green. Scheele's green is of the same character, but not the same pigment as these ; and of the name there are two varieties. Mountain and mineral green are other arsenic greens. Sweinfurth green may be given as a sample of the character of the whole.

Copper oxide	31.24	parts.
Arsenious acid	58.62	"
Acetic acid	10.14	"
	100.00	

Paris green, true to name, should not, in this country, contain adulterations, although cheap Paris greens not bearing the makers name are often found badly adulterated—some shades containing nearly 1 1-2 as much barytes as pigment. These colors are nearly all slow driers and require a considerable quantity of drier. Aside from worse accidents, they affect the painter's eyes unpleasantly, and, for the time, even seriously. The following is a list of pigments which contain arsenic ; they are all injurious to and injured by cadmium yellow :

Sweinfurth's green,
Emerald green,
Paris green,
Castle green,

Vienna green,
King's green,
Scheele's green,
Mineral green,
Poisonous Bremer green,
‘ mountain green,
Munich green,
Swedish green.
New green,
English green,
Brunswick green,
Patent green,
Pickle green,
Swiss green,
Leipsic green,

their names seem endless. They are all very slightly affected by water and more completely dissolved in alkaline and acid fluids through which solution, as well as by powder, and as arseniureted gas, their poison may get into the body. They are affected by glue or other organic matter decomposing, and give off arsenic to its sulphureted hydrogen which becomes then arseniureted hydrogen found in rooms covered with papers holding arsenic colors. Besides these pigments, smalt contains arsenic and the green smalt may contain it.

Sugar of lead ground very fine is a good drier for these colors. Artists, and even those doing finer painting, will do well to buy their emerald and Paris greens ground in oil.

They have, however, a tendency to separate from oil.

Brunswick Green is, in this country, chrome green darkened with black. There are other greens of this name which contain no arsenic (made like Bremer blue), as may be known by their giving no smell of garlic when glow-heated. They are valuable, but somewhat uncertain in composition, and are of a beautiful dark green color.

Green Lake may be made in a variety of ways—1, by mixing together a blue and a yellow lake; 2, from coffee; 3, from the green leaf substance of grass, spinach, thistle heads, etc., fixed on alum, which gives a leaf green lake; 4, sap green, made originally from a Chinese plant, now made from buck-thorn berries;

5, from sulphate of copper (mineral lake green). The first is the common method.

Manganese Green.—This color might, in some cases, replace the poisonous green in common painting. It is made in various ways of manganese baryta salts.

Manganese greens and blues are not very stable in oil, as all manganese compounds are affected by organic compounds.

MIXED GREEN (MANUFACTURED.)

Chrome Green, *Vermilion Green*, *Vermilion* (*bright and dark*), *Oil Green*, *Leaf Green*, *Moss Green*, *Silk Green*, *Bronze Green*, *Emerald Green*, *Milori Green.* In producing these colors the following pigments are used.

(*A*) *Paris Blue.*—It may be used fresh, and with its full complement of water of composition, or in a dry condition. Silk green needs the purest of Paris blue. It is often better to use Paris blue than Berlin blue or mineral blue, as it contains no dilutants.

(*B*) *Chrome Yellow.*—Silk green of a pure green tone without a shade of olive can only be made from the sulphur-yellow sort. For a chrome green of less pure shade (darker with blue) use the light to dark citron yellow. The leather-colored chrome yellows give greens without brilliancy, shading into olive. The orange chrome yellows give brownish bronze-colored greens.

(*C*) *Dilutants.*—The best is barytes, as it gives greens with more light. Beautiful, well-covering and brilliant greens are made from 10 per cent. of mixed *A* and *B* with 90 per cent. of *C*.

A green of given shade becomes more bluish by addition (*C*), and needs more *B*, as *A* has greater covering power, in order to remove the bluish gray tone.

The number of shades of both yellow and green which may be produced is almost unlimited, to use a strong expression. When using Paris blue "in paste," it must be washed completely free of acids, or these will attack the chrome yellow, and result in greens with little brilliancy.

Colors made in this way require 10 to 15 per cent. of oil, dry well, and, if not in places too much exposed to light, hold their color well. Sulphur gas darkens the yellow, strong light bleaches the blue, so that little by little it becomes lighter (more yellowish gray). As oil color, however, these greens appear and stand better than as water color. Without any binding material to prevent the full activity of the light and air, two hours of exposure will produce an effect.

Test.—The best method of test is mixing given quantities with zinc white, and noting the shade.

Adulterations.—Some chrome greens have a tendency to fade which must be ascribed to their composition. That such pigments as were analyzed by Mr. S. E. Allen* some years ago do not last is not a matter for astonishment.

SAMPLES OF CHROME GREEN.

	I.	II.	III.	IV.	V.
Berlin blue	44.1	32.9	42.4	23.1	26.3
Chrome yellow	18.6	39.1	36.5	30.9	38.8
Barytes	....	26.8	20.7	15.0	11.9
Sulphate of lead	7	....	....	...	6.8
SULPHATE OF LIME	....	....	....	30.6	16.0
Clay	29.4	....	....	....	....
Ferrocyanide of potash	....	...	traces.	...	....

Zinc Yellow Greens.—The zinc yellow (with *A* and

---

* The *American Chemist*, 1876, vol. vii., No. 2, page 47.

C) greens are never olive, but always pure green, in many shades. They vary as *A* and zinc yellow are proportioned in the mixture, but those shading toward yellow are most beautiful. Less of *C* can be used than with chrome yellow greens, and the green is deeper, as it contains less *C*. Twenty or thirty shades of zinc green are sometimes found on the price lists of foreign color manufacturers.

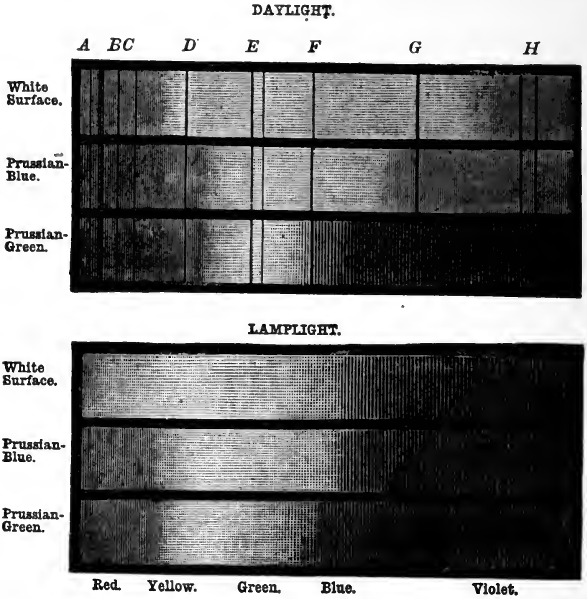
The zinc greens have the same durability as the chrome greens, with the advantage of less tendency to blacken in impure air. In water they produce as yellowish a color as of dissolved zinc yellow.

Green Vermilion is sometimes made from oxide of cobalt and oxide of zinc. Usually it is merely a mixed chrome green. It is also made from ultramarine and yellow wood-dye lake. Or finally, it may be the green ultramarine, which is a less handsome color.

Test.—If it contains ultramarine it will give off an odor of bad eggs on placing it in muriatic acid.

Greens and Terra di Sienna.—All yellows which do not chemically unite with blue give greens when mixed with it. Pure yellow ochre and Terra di Sienna, with Paris blue give a not brilliant but somewhat grass-green color, which has the peculiarity of being proportionately darker in oil without any additional mixture of blue. A bluish bright oil green, made from *A*, *B* and *C*, with 20 per cent. of Terra di Sienna, brought to a paste or ground in a mill, becomes of darker shade, without loss of brilliancy and of a purer grass-green. The darker oil greens will, therefore, often be found to contain Terra di Sienna.

Greens by Mixture with Black.—Blue-blacks give with yellow the purest of the black-yellow greens. Charcoal black with dark chrome yellow of citron to orange yellow shade (with barytes) give the finest sorts. The common sorts are made from yellow ochre, red brown ochres, or umber having by addition of blue a greenish shade; with black a duller, darker shade, which is lightened by addition of barytes.



From Von Bezold on Color. (*L.Prang & Co.*)

The more red in the black, or brown in the yellow, the greater the tendency to brownish shades of green.

Hooker's Green is made from Prussian blue and gamboge, and is said to be more durable than the mixed chrome green(?).

Greens for Artificial Light.—The effect of artificial light on colors is shown by their spectra—*i. e.*, their colors separated by a prism.

As will be seen by the light spaces in the illustration, there are few blue rays, and proportionately more red and yellow rays in lamplight than in the sun's light. Yet yellow colors appear very faint at night,* while carmine becomes pure brilliant red; vermilion a brilliant, but somewhat orange-red; Prussian blue becomes greenish (loss of blue rays—see cut); ultramarine and Cobalt blues (except cerulean blue) become slightly purplish (less blue and more red rays—see illustration, page 356). Quercitron lake does not lose its brilliance by lamp or gas light; the red-wood lakes are more brownish and less red, night blue and cerulean blue (which are slightly greenish by daylight) retain their blue color; all of which facts are useful as tests, as well as guides to use of colors for artificial light.

Quercitron with Paris blue gives greens which do not change color by artificial light, and with indigo carmine greens still more perfect by artificial light.

BROWN.

Brown is the earth color, dirt color, and is difficult to get in clear, pure tint, but when got, it is one of the most beautiful of colors.

As artists' pigments, both because they are affected by water, and also possibly because they contain manganese, they seem less durable as paint (not color) than other pigments (see page 105).

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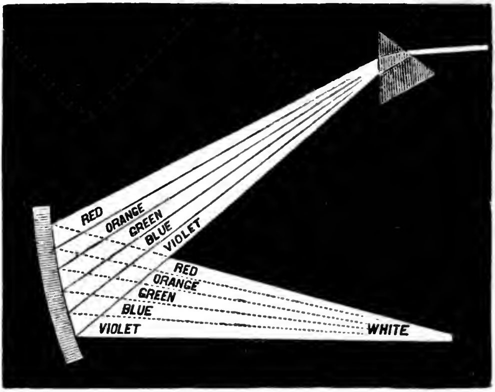
* This is a deception of the judgment; the white wall and other surfaces are yellowish, but are assumed to be white, and pure yellows therefore appear pale, because they present less contrast than by daylight.

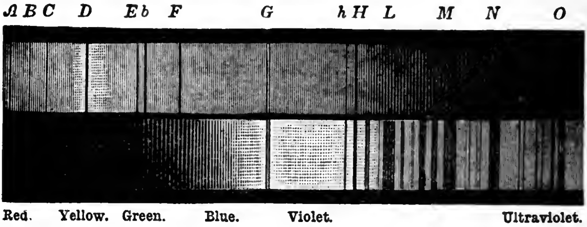
Brown is, we may say, a mixture of colors, and there are browns of almost every hue; mixed pigments tend to produce brown for reasons which should be well understood.



From Modern Chromatics. (*D. Appleton & Co.*)

We separate the rays of white light by passing the light through a prism.

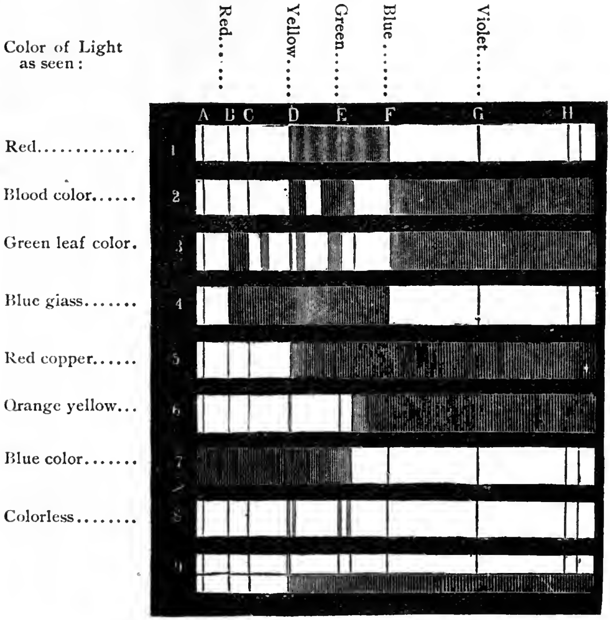
We can also unite the separated rays into white light again by reflecting them from a mirror of proper shape.



From Theory of Color. (*L. Prang & Co.*)

Nearly all colors, except lustre colors—*i. e.*, those produced by metals such as gold and silver, white lead, etc., and also by some of the coal tar colors—are the result of subtraction. For example: White light, less red and blue = green.

Separated Colors of Light coming through Substances, as follows: (1) Permanganate of potash solution; (2) blood; (3) Chlorophyl; (4) cobalt glass; (5) red oxide of copper glass; (6) bichromate of potash solution; (8) oxide of didmyum glass.



"B" and "C" are in the red; at "D" yellow begins; at "E" green, and at "F" blue; "G" and "H" violet color (see page 306.)

The shaded portions represent colors which have been absorbed; the light portions, those colors near the lines to which names are given above the cut; the total of the light portion makes up the color written at the side.

Leaf color (the green coloring matter of plants) allows some of the red to pass through it, and also swallows some of the green. Green leaves are also red, as may be observed by looking at them through two blue glasses and one red glass. Grass is redder than a red brick. Place the brick on the grass-plot and examine it through the above-mentioned glasses.

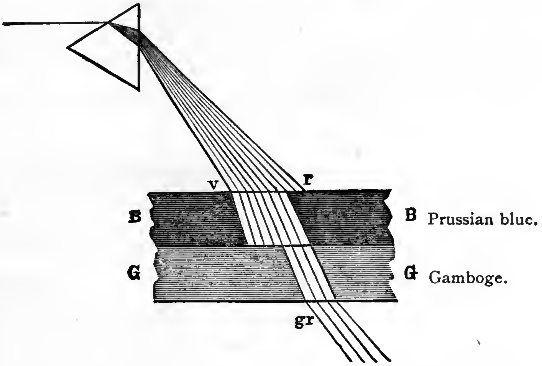
Blue glass (4), it will be seen, shuts out green rays, and allows some of the red rays as well as all the violet rays to pass through it. A red glass, however, is necessary to add to the green, because it shuts out the blue rays passing through the blue glasses. No. 5, red copper, it will be observed, shuts out the blue rays as well as the green ones.

No. 7 is a blue color, but differs very much from the blue cobalt glass of No. 4, in that it shuts out all the red rays. The colorless glass of No. 8, it will be observed, is still dark at certain portions, but it allows nearly all the colors to pass through it which make up a pure white light. No. 9 shows that the glass does *not color the light.* The upper portion of screen, on which the separated light is thrown, is white, the lower division red; the white reflects each color, the red surface swallows all the colors but the red, seen as white space at the left.

Pigments do not color the light, but uncolor it, while it is passing through the little particles of pigment.

The Prussian blue takes out red and yellow rays, allowing the blue to pass through the gamboge. Gam-

boge takes out the blue rays; only the green rays are left, therefore the gamboge will appear green if mixed with



From Theory of Color. (L. Prang & Co.)

*Prussian blue, while mixed blue and yellow lights appear gray, not green.**

The dark and light portions in the cut on page 356 show the various colors absorbed, and those allowed to pass through the particles of the following pigments.

The spectrum of a pigment is easily obtained by painting it on paper and cutting a very narrow slice of color, placing this on a piece of black velvet and viewing it through a prism. The top of the prism must be shaded, to prevent too much light from reaching the eyes. Beautiful spectra, worthy of careful study, can be obtained by this simple method.

In a mixture of ultramarine and vermilion, the ultramarine will absorb the yellow, the green and part of the red rays, and the vermilion will absorb the yellow, the green and the violet,† so that no light is left

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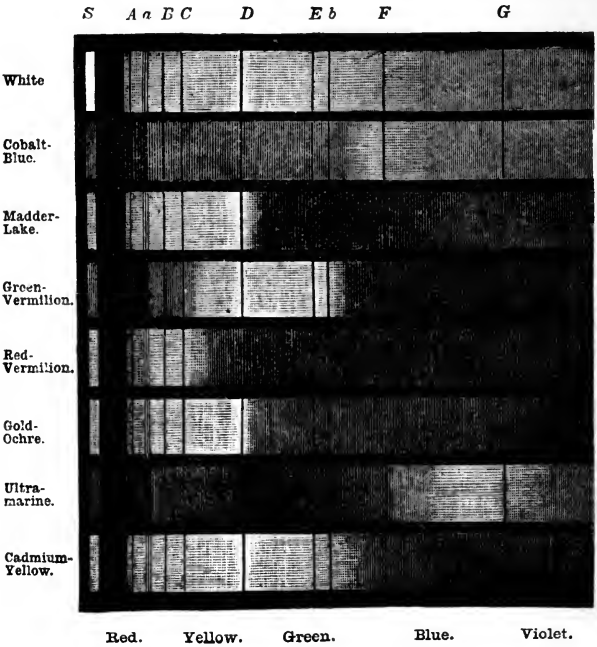
*The same effect is produced in a layer of paint, the color is then reflected back as seen in illustration on page 28.

† See dark portions of the spectra of these pigments in the illustration.

for the eyes but a part of the red which the ultramarine allows to escape, appearing as a reddish brown Mixture of pigments is therefore a process of taking away color, rather than of adding it. The *lights* from vermilion and ultramarine mixed (put together) produce a beautiful purplish violet. Colors must not be



From Theory of Color. (L. Prang & Co.)

confounded with pigments, for as shown by their spectra each pigment has several colors, and their mixture gives its tone of color.

Terra di Sienna or Terre de Sienna.—This is a very beautiful and mild yellowish brown and very transparent color, which, says Bouvier, may develop by its impurities every dismal quality when mixed with mineral colors, especially white lead. Burnt Sienna is a warm transparent orange brown. Both these colors are otherwise very stable, except as regards slight changes by the action of light. Raw Sienna gives good greens. Raw Sienna requires 33 per cent., the burnt Sienna 25 per cent. of oil ; the raw dries well, the burnt, slowly. They come of different grades, and are adulterated with barytes.

Test.—Digest the powder with sulphuric acid **(poison)**, then thin with water ; the color is dissolved, leaving the barytes undissolved, which may then be dried and weighed.

Mahogany Brown is a fine burnt Sienna used for toning woods.

Umber is one of the most useful of all pigments. For the decorative artists it is the best pigment for toning, a very *little* raw umber takes out the fire of bright colors, and softens them. It grays discordant shades and brings them into better relations. It is itself rich in tones—that is, it is somewhat red, somewhat yellow, somewhat green, but still more blue, as shown by its separate colors. Umber which contains very much manganese, and finely washed and carefully ground, is known as chestnut brown, velvet brown, manganese brown, etc. In proportion as umber contains manganese it is valuable. When the brown color shades into green it is known as Italian umber.

The Brown Ochres Burnt are more violet brown as they contain more iron oxide and more reddish brown as they contain more manganese.

Cassel Brown, Cologne Earth or Brown Coal.—The German *Vandyke brown* is still Cassel brown, as in Vandyke's day; the French is burnt umber, the English uncertain but some bituminous substance. Cassel brown is a beautiful brownish black with much transparency and force, not allowing, however, advantageous mixture with white. It is a very slow drier. Vandyke brown is a good glazing color.

Cologne Earth is untransparent, of a dark violet tone. It may be replaced by a mixture of black and dark red or red ochre.

Cappagh Brown is a manganese holding peat, of which there are two sorts.

Spanish Brown is a pulverized and washed brown coal inferior in color and coloring capacity to umber, but of lasting value for roofs.

Madder Brown is a rich russet, permanent and a good drier.

Madder Maroon much the same.

Sepia is a powerful dusky brown, made from the secretions of the cuttle-fish (the same which it uses to darken the water in order to hide itself when in danger or from its prey.) The Italians make a variety from mussels, which, I believe, is more yellowish. Sepia is used in water painting. *Bistre* is also a water color—a beech wood charcoal mixed with gum arabic.

Mineral Bistre or Manganese Brown is a powdered oxide of manganese mixed with gum, for use of water colors. It is a fine deep brown which dries well in oil and is permanent.

Asphalt Brown.—There appears to be among artists an asphaltum mania. Asphalt is a substance never dry but always drying, that is, losing in weight (see page 148), and yet some of the greatest of modern artists, both English and French, have used it to the degree that, it has been said, it is found years afterward trickling down the canvas of their pictures.

It is a beautiful brown pigment, which, if used at all, should first be *burned* to get rid of its oil—the cause of a constant loss of substance. It mixes well with Cappagh brown or umber, and is then less disposed to crack, but until rid of the contained oil is never a safe pigment. *Mummie* is a kind of an asphalt brown.

Berlin Brown.—An oxide of iron from red-heating Berlin blue in the open air. It is a transparent brown like the asphalt and durable for common use.

Chrome Brown.—Natural browns are so numerous that artificial brown pigments are in little demand, but some of the chrome browns have good qualities. Chromate of iron is a beautiful brown which may be made darker by heating; it has a remarkable degree of covering power and may be largely diluted with chalk. By mixture with blue it gives beautiful shades of olive and bronze greens.

Chromic Acid Copper Oxide and Manganese Oxide.—Much like the former, but more red brown, and by heating black.

Mixed browns from red, yellow, black and blue may be produced to the taste of the mixer.

Intense deep Brown, Berlin blue, dark ochre, carmine lake. A brown of still more force and depth: Berlin blue, Indian yellow, burnt carmine lake, etc.

Gray.—Zinc ore (zinc blende) ground gives a gray color, *zinc gray*. Also a mixture of white clay and lamp black, known as *silver gray.* Also a mixture of various whites and blacks. Light gray is produced by 1-60 part of lamp black with white lead or zinc.

DROP LAKES.

Lakes for glazing made of dyes mixed with gum are known as soft colors or drop lakes, although the latter name applies to Brazil wood lakes especially. Yellow colors are made with the same dyes used for yellow lakes. Blue is best from blue carmine, and is mixed with gums and sugar or gums and malt extract. Other colors are green, made from yellow, lake and blue; violet, from dye woods with a little ammonia.

Good tinting and soft colors, but affected by light are made from the tar colors: Fuchsine in alcohol, eosine in water, coralline in alcohol (orange yellow) and with dilute ammonia (orange red). Blue is given by Lyons blue, green by methylgreen. Nyrosin in alcohol gives brown and black.

Carriage and Wagon Pigments.—These will be white lead, zinc white, for outer coats, flake white and sometimes silver white and cremnitz; for blacks, lamp black, drop black and ivory black; as principal yellow, chrome yellow, also Dutch pink, cadmium yellow, for a little luxury, and yellow ochres for its opposite; Naples yellow for painted cane work and for fine striping; Indian, Venetian and Tuscan reds and vermilion will be body reds, and use will be found for all the lake colors; chrome green will be the green, under various names (Brunswick, Milori, etc.), Paris green, verdigris and Guignet's green may at times be used advantageously; blue, will be Prussian blue, artificial ultramarine, and occasionally cobalt blue; brown will include Vandyke brown, both siennas and umbers

Car Pigments will be much the same, but less in number, and more of the earth colors will be used.

A Decorator's Advice.—The decorator may confine himself to a few pigments. White lead he will avoid, using zinc white in its place. The earth pigments he will make large use of, especially yellow ochre, raw umber and burnt Sienna—of burnt umber he may use a little; artificial ultramarine is his best blue, and occasionally a little cobalt may be used. Paris blue is too changeable. Red will largely be iron oxide, Indian red and medium Venetian red; a little vermilion will also be needed at times. Green will very largely be chrome green (medium); a bronze green may be made from artificial ultramarine blue, yellow ochre and a little raw umber. Raw umber will be found especially valuable in toning other pigments; ultramarine blue will often need a little of it. The lakes will seldom need to be used. Bronze powder will replace gold leaf most advantageously, as it is easily applied.

Muckley's list of Permanent Colors.—(From his *Hand-book for Painters and Art Students.*)

These colors are stable for water color paintings as for oil, with the exception of flake white. Chinese or zinc white should always be used in water color painting.

WHITES.

Chinese white,
Zinc white,
Flake white (white lead),

YELLOW AND ORANGE HUES.

Aureolin(?),

BLUES.

Genuine ultramarine,
Artificial ultramarine,
French ultramarine,
Cobalt,
Cerulean.

Yellow and Orange Hues.

Yellow madder,
Yellow ochre,
Transparent gold ochre,*
Raw Sienna,
Burnt Sienna,
The orange cadmiums,
Orange vermilion,
Naples yellow,
Field's orange vermilion.

Reds.

Chinese vermilion,
Vermilion,
Venetian red,
Light red,
Red ochre,
Indian red,
Madder carmine,
Rose madder,
Pink madder.

Greens.

Transparent green oxideo fc hromium,
Opaque green oxide of chromium,
Viridian,
Terre verte.

Purples.

Purple madder,
Gold purple cassius,
Reuben's madder.

Browns.

Vandyke brown,
Raw umber,
Burnt umber,
Brown madder,
Reuben's brown.

Gray.

Ultramarine ash.

Blacks.

Blue black,
Ivory black.

List of colors of the second order permanence.

Most of these colors change when used alone. All of them change when combined with each other.

Whites.

Cremnitz white,
† Cadmium white.

Yellows.

Lemon cadmium,
Chrome yellow,
Citron yellow,
Zinc yellow,
Gamboge.

Blues.

Smalt,
Prussian blue,
Antwerp blue,
Cyanine blue,
Indigo blue.

Greens.

Veronese green,
Emerald green.

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* Nearly all gold ochres contain chrome yellow which, of course, impairs their permanence. An analysis of gold ochres in artists' tubes (European manufacture) discovered chrome yellow in every one. (D.)

† These pigments not known to us.

Reds.

Carmine,
Crimson lake,
Scarlet lake,
Purple lake,
Indian lake,
Florentine and Hamburg lakes,
* Kermes lake.

Browns.

Brown pink,
The sepias.

Muckley also gives in his hand-book lists of permanent but unnecessary, and of fugitive colors. The book has many valuable facts for the artist, but is not a very full one.

AN ARTIST'S ADVICE.

A great deal of unnecessary trouble may be avoided by a careful selection of such colors as are best adapted to render the innumerable tints of nature. My own palette is as follows, the colors being arranged in this order from right to left. I mention the order, as I have found it convenient in practice, and it is always as well to adopt a fixed position on the palette for each color, so that the brush instinctively seeks it when it is wanted :—

Brown ochre.
Yellow ochre.
Naples yellow.
White.
Orange vermilion.
Light red.
Chinese vermilion.
Rose madder.
Burnt sienna.
Emerald oxide of chromium.
Cobalt.
Ivory black.
Vandyke brown.

I believe that these colors will be amply sufficient for all kinds of flesh painting, and they are, when good, quite permanent. There are some yellows and greens, especially such as occur in landscapes, which demand an additional pigment. The choice of

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* These pigments not known to us.

this is one of some difficulty, having due regard to the question of permanency. Perhaps a very pale cadmium is the best (?). With this addition there are few hues in nature that cannot be matched with these colors, making allowance for an occasional loss of brilliancy, which is inevitable in making the strongest chromatic effects with mere pigments. I have the less hesitation in recommending this palette as I have adopted it from the one used by Mr. Alma Tadema. I have added Vandyke brown to the colors he uses, but this is the only difference that I have made.—*John Collier* (*A Primer of Art.*)

PREPARATION OF PIGMENTS FOR USE—COLOR GRINDING FOR CARRIAGE PAINTING.

The process of grinding the various colors, necessary to render them soluble in the vehicle or liquid with which they are applied, is performed by either grinding in a hopper mill, by manual or steam power, or by hand grinding with a pebble muller upon a slab of marble or porphyry. Any other stone will answer the latter purpose provided it be not of a porous nature, so as to absorb the oils or varnish used in the grinding, as this would cause the stone to clog or impede the grinding process. When the grinding is done by a stone hand-muller, a long, thin, tapering, well-tempered steel palette-knife is used, both to clear the stone and muller of the color, and to concentrate the pigment during the process of grinding.

Assuming that a quantity equal to a gill of color has been ground in either oil or varnish to the consistency of cream, it will require to be thinned down ready for use by rather more than a similar quantity of turps ; and it should be thoroughly mixed together by stirring in a large pot, and with the tool or brush with which it is intended to apply the color, occasionally clearing the brush by drawing it over the edge of the palette-knife held over the color pot. This will not only clean the brush, but will also have the effect of mixing the colors to a uniform shade.

All color, after grinding and mixing, should be strained through a fine hair sieve or a piece of fine muslin, in order to remove any grit, dirt, "nibs," imperfectly ground color, or brush hairs, that may become detached in the mixing of the color. By attention to this straining of color (too often neglected) the painter will be saved considerable time in facing or flatting down, besides not requiring to remove so much of the surface for glazing.

The color, after being ground, should be strained into a pot, containing about a gill of varnish ; this is what is termed "varnish color." It is not requisite to grind either ultramarine or vermilion, if used as varnish color ; it is sufficient if they are thoroughly mixed with the varnish, and strained when they are ready for use.

MIXING GROUND COLORS.

In mixing fancy or ground colors, add sufficient gold-size to the dry color to form a thin paste, which, when thoroughly mixed by grinding, should be reduced to a working consistency by the addition of turps. This is what is known as "quick color," and it is used for hurried work. In making up color for good work, add a large tablespoonful of raw linseed oil to each pint of color.

When several pigments or colors are necessary to be mixed together in order to produce a desired shade, instead of mixing the dry colors on the stone and grinding them together, as is occasionally done, each color should be ground separately, and then one added to the other till the desired shade is obtained.

Painters should avoid using a greater number of pigments in mixing shades than are absolutely necessary to produce what they require.

Colors should always be kept in a dry place, as dampness will affect the shade of most colors. All color pots when empty should be placed in a tub or earthen vessel containing strong potash water, which will remove all the paint from the pots, and when rinsed out in clean water they will then be again ready for use. Hand pots used for varnish can be cleaned in a similar manner.—*G. F. Budd, in the Hub.*

FOR ARTISTIC PAINTING.

Copaiba balsam may be used as a binding material for those pigments (as verdigris) which are affected by oil. They may then be mixed with oil. Copaiba balsam may be mixed with poppy oil, which has less tendency to change color than has linseed oil. Pure copaiba balsam has an acid reaction and mixed with a third of its volume of caustic ammonia (*Liquor ammonii caustici* of 0.96, made from ten parts of ammonia and ninety parts of water), should give a clear solution.

WASHING PIGMENTS.

The earthy pigments (ochres, terre de Sienna, etc.) often need washing to purify them, and especially to reduce the particles to greater fineness. The illustration on page 294 represents the method; it is merely necessary to substitute tall glasses for the casks. One-quarter of glass A should be filled with pigment, water being added until the glass is full, and the mixture stirred with a glass or wooden rod. When the pigment has somewhat softened and the larger particles have settled, one-half the contents of A is poured into B, and more pigment and water added to A. Repeat this process until B is full, and then pour one-half of B into glass C. Add more pigment to A and pour some of the deposit of B into A, then add water and proceed as before, keeping the rule that only one-half the contents of one glass is to be poured into the next. When C is full, one-half of its contents may be poured into D, and part of the deposit in C poured into B.

The contents of each glass is then poured through a filter and the powder dried; D will give the finest particles, C the next in fineness, etc.

It is not necessary to use so many glasses; and as it is sometimes difficult to dry the powders, and as the remaining water is injurious *to the pigment especially*, to varnish, and to a less extent to oil, alcohol may be used. Any alcohol remaining in the pigment after it has been filtered will do no injury. If water be used and the pigment is not dried, the oil may be heated after the pigment is rubbed with it to drive off the water. Alcohol being lighter than water, finer particles of pigment can be got by one or two washings—*i. e.*, using two or three glasses.

It should not be forgotten that lakes and organic colors (especially with a starch base) cannot with any safety be heated with oil to rid the mixture of water.

CHAPTER VIII.

THE CHEMICAL RELATIONS OF PIGMENTS.

A mixture is a mingling together of the particles of substances, and as the painter is constantly making and applying mixtures as a business, it is well that he know something about them.

The particles of two substances mixed together may affect each other without radical change in any particle, as, for example, sugar may be dissolved in water until its particles become so fine we no longer see them, and yet we have merely a mixture of sugar and water. A sponge may attract, and so soak up, the particles of water in a basin, until the water has entirely disappeared within the sponge, nevertheless we have still merely particles of sponge and drops of water. Two pieces of wood may be held together first by the stickiness of glue and then by its hardness without much change in the particles of the wood or of the glue. The pulling and contraction of oil in drying is not in itself a change in the nature of the particles of oil, but only a change of place, or movement among them, caused by a previous change in the nature and substance of the oil particles.

Paint may change in color from white or colorlessness to yellow, merely by the appearance of fine checks or cracks caused by contraction. It may also change color by a change in the nature and substance of the oil particles. Varnish and paint under it may change color by the separation of the gum in the varnish from the dried oil. The paint under the varnish may also, as is sometimes the case with ultramarine, separate from the oil as gum does from varnish and in this way cause a change of color without change of nature in either the particles of oil or of the paint; but only such paint substances as are affected by water are likely to undergo this change; ultramarine, for example, being a kind of earth, is especially liable to it.

All the above changes may take place without chemical change,* that is, change of nature, in the particles of paint or pigment.

It is easy to attribute changes of color to the fading or blackening of the pigment particles when they are in no wise at fault. This change of nature, as we have termed it, is either an unlinking of the chemical elements which, linked together, make up a particle of the pigment, or it is, and much more commonly, the linking of another chemical element to the pigment, as when white lead becomes blackened by sulphur gases.

This change is as follows:

$$\text{White lead, } \left\{ \begin{array}{l} \overbrace{\text{Lead.} \qquad\qquad\qquad\qquad \text{Sulphur gas.}}^{\text{Sulphide of lead.}} \\ \text{Carbonic acid gas.} \end{array} \right.$$

As shown by the diagram the sulphur gas becomes linked with the lead, forming particles of a new substance—sulphide of lead—which is black. If a certain union of sulphur acid had taken place, another substance—sulphate of lead, which is white—would have resulted; in fact, blackened lead paint, or sulphide of lead, is made white by the sun, which changes it into white sulphate of lead. It does not always occur, therefore, that sulphur acid and lead uniting produce a black colored substance; but this is commonly the case.

The effect of gases from gas lights upon the pigments of pictures is of like nature, and *perhaps* an important factor in changes.

All lead and copper pigments may change color, as above, by the action of impure air, which commonly contains sulphur gases caused by the burning of coal, or the rotting of manure, or of other animal or vegetable substances. Animal and vegetable substances

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* For the chemical changes in oil as affecting the color of pigments we must refer to Chapter IV.

contain sulphur. Their fleshy substance, as it breaks up in rotting, produces ammonia, which attacks the oil of paint and varnish, separating it into fine particles of a new compound (a soap of ammonia and oil), causing a change of color; while the unlinked sulphur gases become linked with the white lead or other lead pigment of the paint or with the lead drier of varnish.

Pigments changed in color by sulphureted hydrogen—ammonia gas.

White lead,	blackened.
Red lead,	darkened.
Chrome yellows and mixed chrome greens and yellows,	blackened.
Naples yellows,	"
American vermilion,	darkened.
Mineral blue and all copper blues, blues and verdigris,	blackened quickly.
Greens containing copper,	less quickly darkened.
Prussian blue, Berlin blue, etc., indigo (by damp air),	bleached.
Gamboge,	darkened by ammonia gas.
Bismuth, Antimony, } Whites,	blackened by sulphureted hydrogen.

Pigments containing sulphur darkening and darkened by white lead, chrome yellow, Naples yellow, etc., by formation of sulphide of lead.

Vermilion,	if containing, as is commonly the case, sulphur free from or only loosely combined with the quicksilver.
Cadmiums yellow,	if containing free sulphur or possibly if containing sulphur combined with zinc.
Artificial ultramarine,	in proportion as it contains free sulphur.

The bright and pure red iron oxides.

Zincs containing small quantities of sulphuric acid and all zinc sulphates exposed to heat.

The following pigments have peculiar chemical relations.

Naples yellow not only contains lead subject to change by sulphuric gases, it is a compound of antimony anhydride, which is quickly affected by iron, as the blade of a palette knife, the iron in ochres, Paris blue pigments, etc.

Cadmium yellow, must not be used with copper colors of any kind.

The Madder Lakes, especially toned with carmine, may quickly be affected by *white lead* (flake white, etc.) if turpentine be added to the mixture.

White lead is injurious to Paris blue, carmine, and to nearly all the organic colors, but these changes take place more rapidly under the influence of sunlight, and will be considered later.

Lime in its caustic condition is destructive to the majority of fine pigments. Chalk (carbonic acid lime) and gypsum (sulphuric acid lime) in dry powder are not necessarily destructive, but as all paints are exposed to dampness, and as many pigments are somewhat *acid*, changes may follow on mixture. Walls covered with several coats of oil paint can of course have no destructive effect on pigments.

Pigments which may be affected in color by contact with chalk as adulteration or otherwise.

Paris or Berlin blue,	bleached.
Mixed chrome greens, and yellow,	loss of blue tone.
Copper blues containing Berlin blue,	loss of fine tone.
Paris green,	becomes yellowish green.
Copper blues which are acid,	become greenish.
Carmine redwood lakes,	become violet.

All organic colors may be affected. Chalk in white lead or zinc white easily produces a yellowish white when mixed with oil.

Pigments affected by lime walls.

All those in the above list, the effect being more powerful as the lime is caustic.

Madder lakes,	blued by lime but not affected by gypsum wall.
Chrome yellow,	becomes reddish.

In addition to these changes, oil is saponified by lime, and by wet chalk, forming oxy-linseed oil acid, which quickly becomes yellowish in the absence of sunlight. All oil-painted walls change color, and picture frames hung on wet walls leave their photographs in reddish yellow.

Pigments little or not at all affected by lime, and in various degrees eligible for fresco, distemper and crayon paintings.

WHITE.

Barytic white,
Pearl white,
Gypsum, and all pure earths.

YELLOW.

Yellow ochre,
Oxford ochre,
Roman ochre,
Sienna earth,
Stone ochre,
Brown ochre,
Indian yellow,
Zinc yellow (genuine),
Patent yellow,
Naples yellow,
Massicot.

RED.

Vermilion,
Red lead,
Red ochre,
Light red,
Venetian red,
Indian red,
Madder reds.

GREEN.

Green verditer,
Mountain green,
Oxide chrome green,
Mineral green,
Emerald green,
Verdigris and other copper greens,
Zinc cobalt green.

PURPLE.

Gold purple,
Madder purple,
Purple ochre.

BROWN AND SEMI-NEUTRAL.

Bone brown.
Vandyke brown,
Rubens' brown,
Bistre,
Raw umber,
Burnt umber,
Cassel earth,
Cologne earth,
Antwerp brown,
Chestnut brown,
Asphaltum,

BLUE.

Ultramarine,
Smalt, and all cobalt blues.

ORANGE.

Orange mineral,
Orange chrome,
Orange ochre,
Mars yellow,
Burnt Sienna earth,
Light red, etc.

BROWN AND SEMI-NEUTRAL.

Mummy,
Ultramarine ashes,
Manganese brown.

BLACK.

Ivory black,
Lamp black,
Frankfort black,
Mineral black,
Black chalk,
Indian ink,
Graphite.

The above list is from Field's Grammar of Coloring. The copper greens and the more acid copper blues (excepting *lime blue* and *Bremer blue*) change somewhat, as do also the madder lakes (blued). The list, with these exceptions, will represent fairly well colors which may be used with lime solution, in distemper and fresco. Common lamp black, however, with lime gives a reddish black, the best birch wood coal black may be used.

Iron Pigments.—Field gives the following among other pigments as affected by iron, and pigments containing it: Sulphate of lead, *blanc d'argent*, King's yellow, Naples yellow, iodine scarlet, carmine, scarlet lake, blue verditer, mountain blue and intense blue verdigris. The writer has no evidence as to these except as regards Naples and King's yellow, perhaps iodine scarlet and such copper blues as are acid, and of the effect of the lime in ochres on the carmine lakes, and upon the copper colors. In general, however, it is better not to use a steel palette knife with finer pigments.

Poisonous Pigments.—The relations of pigments containing arsenic (arsenious acid, sulphureted arsenic, etc.) to others is of little practical importance, because these are very little used. The old yellow arsenic or yellow orpigment, King's yellow, Chinese yellow, etc., are injurious to a large number of colors. More important is it to give attention to the poison (arsenic) in Paris green, fuchsine, cochineal lake, and in many water colors.

Fleck's attention was called to water colors by the poisoning of a young draughtsman who was accustomed to wet his brush in his mouth. He found, of one celebrated firm's manufacture, samples to contain arsenic as follows:

Prepared water colors.	Contained arsenic.
Sepia	1.10 per cent.
"	0.98 "
Terra di Sienna	1.76 "
" " "	2.23 "
Vandyke brown	0.81 "
Bistre	0.67 "
A green color	0.82 "

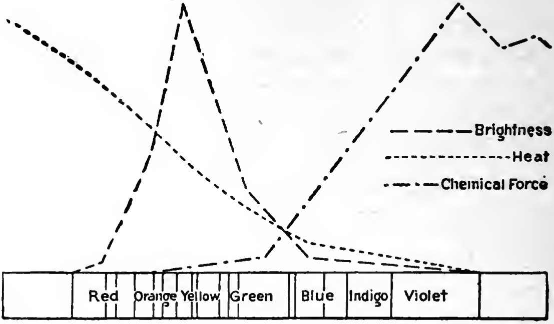
Indian red, ochres, umber, etc., contained less than one-half of 1 per cent. (0.50).

Other brands contained variable amounts—one terra di Sienna, 3.14 per cent. Some brands were comparatively free of arsenic.

THE EFFECT OF LIGHT ON PIGMENTS.

Oil is bleached by sunlight, but reddened by heat and by long heating by the sun's rays. The sun's rays are both a chemical force and a source of heat. The blue rays have the most power in changing substances chemically (linking or unlinking); the red rays are the hottest.

The dotted lines in the engraving on the next page show the proportionate amount of brightness, heat and chemical power in each kind of ray named below.



It is probable that oil is made colorless by the blue rays (chemical rays), and in the absence of these varnish turns yellow.

White lead itself is not much affected by sunlight, but white lead which has been blackened by sulphur gases is made white, the black sulphide of lead mixed with white being changed by the sun to white sulphate of lead.* The sun is the only cure for all color diseases of white lead, and there is some reason to believe the cure is more rapid in autumn under a sea air.†

Vermilion has already been spoken of at length on page 317.

Iodine vermilion is more quickly blackened than quicksilver vermilion.

Chrome yellow and Naples yellow and raw Sienna and Vandyke brown are very slightly affected by light.

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* Shonbein, Salter, and others.

† See Hoffman's Chemical Technology, English edition, p. 72.

ORGANIC COMPOUNDS AS COLORS.

These form a class by themselves; they need treatment as a class. They are:

Red.—Madder dyes, cochineal carmine, coal tar colors, redwoods, as Pernambuco wood, Brazil wood, Japan wood (from Japan, Java, etc.), Nicaragua wood, sandal wood, and African redwood, in some, if not all, of which the coloring matter seems to be of like character. Safflor or safflower.

Yellow.—Buckthorn berries, quercitron, Indian yellow, gamboge saffron, yellow wood of the Antilles and of Siam and also (less stable) of South Europe, Berberine (from the barberry), curcuma (turmeric), dyer's weed (reseda luteola), annatto. From these are produced the yellow lakes; the best from Persian berries and quercitron. Turmeric gives beautiful colors, but is changeable. Annatto gives a strong yellow or reddish yellow. Saffron is too expensive for any considerable use. The most common yellows are, perhaps, the yellow woods.

Blue.—Blue wood or Campeechy wood, catechu, Paris blue, Prussian, etc. Catechu gives very stable browns.

Mixed Colors.—Violets, lilacs and intermediate colors, tints and shades are produced partly by chemical reactions upon the organic coloring matters, partly by simple mixture.

The destructive agent of all these substances is light, or more definitely the action of oxygen under the influence of light. It was found (in investigating dyed goods) that indigo, archil and safflor were very stable in the light, if no oxygen was in contact with them. Also turmeric was found to bleach much more quickly in oxygen gas, than, for instance, in nitrogen gas.

This will explain why varnish is necessary to all lake colors, nearly all of them without varnish have (with the exception of madder), a comparatively short duration as pigments. Oil, however, is a protection, and chrome greens (made with Paris blue), which change as dry powder in one hour of sunlight, will in diffused light under oil last perhaps many years. The same may be said of aniline colors, although their duration is not nearly so long in oil—not more, perhaps, than a few months.

To nearly all these substances *white lead* is more or less injurious—excepting only madder. It is possible that lead and manganese driers injure these pigments directly and also by discoloring the oil.

Animal charcoal (bone or ivory black) is a strong bleaching agent, and it is possible for it to uncolor these bodies. The oil protects against this influence, but where long stability is desired it is better to use the other blacks with organic pigments.

Chrome yellow has a destructive effect on all organic pigments in sunlight, by the action of the chromic acid.

To speak more definitely :

Lakes.—All lakes are subject to change by light ; the only stable ones are the madder lakes (genuine).

Bouvier speaks of a Dutch madder lake (clay base), which had held its color for 30 years. He tested numbers of lakes of all kinds and from various countries, but found that all bleached in the sun in six weeks or two months. Rose madder may fade somewhat, but this may be due often to adulteration by carmine.

Genuine Carmine lakes are very quickly affected by light, but much less so when the air is shut out by varnish ; white lead, however, is even more destructive than air. The stability of a carmine lake is in proportion to the quantity of color it contains, but especially, it is due to absence of strong light, when the color may last many years.

Red wood and all the yellow lakes (except Indian yellow) fade. Quercitron is the most stable of the yellow dyes.

Rose pink and Dutch pink have the least stability of all reds and yellows. Violet lakes have better stability.

Scarlet Red (iodine—quicksilver) is made yellow, brown, and then black, by sunlight.

Berlin blue, or rather Paris blue, which is the stock color for making blues and greens, consists of :

Potash	37.22	parts
Iron	12.91	"
Cyanogen	37.05	"
Water	12.82	"
	100.00	"

Chevreul found that in a vacuum Berlin blue became bleached (by separation of the cyanogen) and darkness again restored the color. This, or some like change, takes place under all circumstances in which Paris blue is exposed to the light, but whether it is observed by the eye depends upon the amount of the Paris blue present. In the so-called chrome greens on our window blinds, the bleaching is very evident for two reasons : (1) Because there is only a little of the Paris blue present, and, (2) because they contain gypsum and other alkalies, as well as lead, which hasten the change. The pure Paris blue in the direct sunlight becomes greenish, and of brighter and brighter green. Turnbull's blue is much the same compound, but is thought to withstand the sun's rays somewhat better.

The following colors are made with Paris blue, more or less diluted with barytes, chalk, etc.:

Berlin blue.

Chrome greens in great variety and various shades of "yellow,' containing more or less Berlin blue.

Green vermilion.

New mineral blue.

Hooker's green.

Prussian green, etc.

A variety of mixed colors.

Indigo is much more stable out of the air ; it is especially acted upon by damp air.

Prof. Rood found that following lakes were changed by light after an exposure of seventy hours :

Rose madder fades slightly, becomes more purplish.

Prussian blue fades somewhat.

Hooker's green becomes more bluish.
Gamboge fades and becomes more gray.
Burnt madder fades somewhat.
Neutral tint fades somewhat.
Indigo fades somewhat.
Brown pink fades greatly.
Violet carmine fades greatly, becomes brownish.
Yellow lake fades greatly, becomes brownish.
Crimson lake fades out.
Carmine fades out.

"To this we may add that rose madder, burnt or brown madder, and purple madder all are little affected by an exposure to sunlight for seventy hours. Pale washes of the following pigments were completely faded out by a much shorter exposure to sunlight:"

Carmine,
Full red,
Dragon's blood,
Yellow lake,
Gall-stone
Brown pink,
Italian pink,
Violet carmine.

As to the chemical activity of light upon pigments, it has been shown that,

First.—The effect of light is according to the nature of the substance—partly oxidation, partly unlinking of the chemical compound.

Second.—Every ray of light which acts chemically on a pigment must be swallowed by that pigment so that the chemical effect of light accords with the effect of color to our eyes—*i.e.*, to those colors which are taken out of white sunlight, and not reflected by the pigment, are the active rays in producing change. Thus red aniline color is not affected by red rays alone, but blue and violet rays alone soon bleach it out. The leaves of flowers (placed on paper) bleach in every kind of ray, but most rapidly in those rays which are complementary to the color of the leaf—*i. e.*, yellow flowers in blue light, violet in green, blue in reddish yellow light.

Third.—But not only those colors which we miss out of the light are active, but that portion of the whole light and of every color we see reflected, which the body retains. White paper reflects, for example, only about 40 per cent. of the light falling upon it, 60 per cent. being absorbed.

Fourth.—The effect of light varies with the condition of the atmosphere, and is not the same even on clear, bright days. On this account there is no absolute certainty as to exact force of special rays.

Fifth.—With such pigments as carmine, madder and the aniline colors, much of their stability depends upon the quantity of coloring matter present.

The Testing of Colors.—Pigments may be tested by mixing them with a solution of gum and painting the mixture on heavy white paper exposed to the sun. In this way the effect of light and air is produced more quickly, and a pigment which will bear six months of sunlight with gum, will certainly last in oil eighteen months or two years. In general it may be said that colors in oil which remain unchanged for four or five years are entirely permanent.

Protection of Colors.—Pigments affected by light, especially the lakes, must be protected by varnish ; mixture with oil colors will not be sufficient. Colors displayed in show windows, the colors of specimens in zoological collections, need protection to prevent rapid fading. Capronier of Belgium has investigated this matter, and has found by experiments upon the wings of insects that yellow light has least effect, and recommends not only yellow glass for cases, but yellowish curtains and coverings. In Switzerland like attention seems to have been called to show windows : a slightly yellowish tint of glass is recommended as protective, or in place of it, a thin coat of copal varnish (perhaps spirit varnish would be best) over common glass. The ceilings and surroundings, curtains, etc., would also be more protective if yellowish.

Heat and Color.—The effect of oil colors in producing heat under the sun's rays may be seen in the following experiments :

Four painted (some time since) bottles of water, corked, each containing to a certain line 100 cubic centimetres; and two smaller bottles* of water, of uniform capacity, are placed in the sun on a warm, clear day, the first set at 7:30 A. M., and the others as indicated :

	Pullman color, twice varnished	Chrome yellow, twice varnished.:........	Red lead............	Paris green...........	*White lead.........	*Paris green..........
	Deg.	Deg.	Deg.	Deg.	Deg.	Deg.
First examination....................	69	69	......	......	69	69
Later...........	105	94	69	......	90	104
"	112	100	96	72	96	111
"	118	107	105	105	103	118
"	125	112	112	115	107	125

10.40.—At this hour the sun was less bright and temperature of hotter bottles fell.

A bright May day:

	Temperature of bottles.	After an hour in the sun.	Rise.
The red lead	65	92	27
Paris green......................	65	100	35
Two coats of varnish over:			
Pullman color......................	62	104	42
Chrome yellow....................	62	88	26
The same on a warmer day, after several hours			
Pullman color......................	62	116	54
Chrome yellow....................	62	103	41
Colors mixed with varnish:			
Red lead..........................	62	102	40
Paris green......................	62	113	51

To show the little influence of kind of surface:

A very bad surface of chrome yellow over a very hot green color......	102
A newly varnished Paris green......................	115
White lead................	99

It will be observed that one hour in the sun increases the difference of heat under the colors to a point which does not seem to be surpassed afterward.

Whenever a cloud covers the sun, the bottles begin to lose heat; those covered with the warmest colors losing heat (as they gain heat) most rapidly.

Two coats of varnish over:

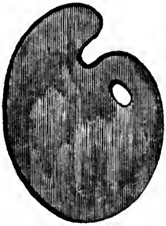
	In the sun.	Out of the sun.
Pullman color	110	94
Chrome yellow	100	90

Unless the day is cloudless, therefore, the bottles of various colors tend to approach each other, because of the greater loss of heat from the warmer color at every obscuration of the sun.

The following results were obtained by Krieger:

Shirtings of different colors were placed in the sun and the rate of heat absorption noted.

Black	208
Light blues	198
Dark green	168
Turkey red	165
Light green	155
Dark yellow	140
Pale sulphur yellow	102
White	100



CHAPTER IX.

DECORATION BY COLOR.*

It is not a question of how much we are to do, but how it is to be done.—Ruskin.

Decoration.—Decoration serves no purpose to things, it is solely for the eyes, but it should have the appearance of serving things; to them it is as dress, and should bring out good points of construction, offset defects and avoid displaying itself.

Its rule is immediate satisfaction to the eye; to the mind lasting satisfaction when novelty has gone and all the points are known.

Decoration cannot be arbitrary. You may, if you please, paint the floor deep blue, the ceiling brown, the walls black, but if there is no apparent reason for such an upsetting of nature, one cannot like your room; it is reasonable to color a ceiling blue or gray, a floor dark, and the side wall to represent an atmosphere of color lighter than the more solid wood-work, because all this is after the order of nature; light comes from the blue or gray sky, the ground is dark and the broad spaces are always filled with air.†

It is reasonable to make the hall color darker, because rooms opening from it then appear lighter; be-

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*In the preparation of this chapter the Author is much indebted for assistance to Mr. William H. Day, Architect and Decorative Artist, Art Workers' Building, New York.

†The atmosphere has color, and by its reflection of sunlight destroys shadows, which on high mountains become frightfully strong and dark.

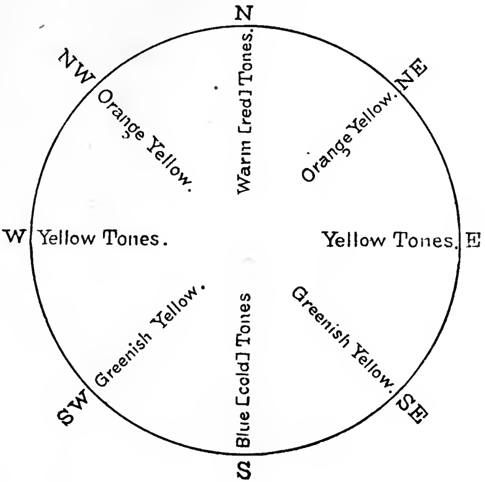
sides, it is narrow and they are wide and should look wider. Dark and red things come nearer light and bluish colors are farther away. We do not see blue dots and red dots at a certain distance at the same time.

A somewhat dark wall color gives a cosy room if there is light enough, and perhaps for the same reason that a quiet nook in the woods is cosy—*protective* shade, quiet and rest are associated ideas. In a wide room light walls seem carried away, but in a little room light wall colors and blue curtains enlarge and make its littleness pleasanter than mere bigness.

Who decorates for the mind works mindful of all little discoveries which people are sure to make who are seeing a thing day by day. Decoration for the eye alone grows poor by looking at ; richness is not in display, but in these discoveries of little things : little tones, little illusions, little touches of nature, little fitnesses to incidentals in carrying out a little idea—itself not of any importance, merely a pleasant conceit.

The amount of light and the size of the room are the chief factors in determining the direction of color. The following diagram illustrates the method of dealing with those varieties of light due to the "aspect" of the room. The north light is whitish to bluish ; the south light has the yellow and purple, morning and evening tones, and the glare of noonday ; the east and west lights have the yellow and purple but for a little while, the morning glow being followed by the bright dispersed light of the day, the evening gold and purple by the gray twilight.

This is, of course, a pleasant exaggeration of what is necessary to observe in regard to lights ; of greater importance is it to have light sufficient. Yellow is the reflecting color, and the keynote for dark rooms.



The difficulty of using color richly lies in the richness of little tones in natural coloring. Natural colors are somewhat dull, the blue sky is the only large expanse of pure bright color; but every natural thing*

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*If a painter represents a sheet of paper in a picture by a uniform white or gray patch, it will seem quite wrong, and it cannot be made to look right till it is covered by delicate gradations of light and shade and color. We have been in the habit of thinking of a sheet of paper as being quite uniform in tint and yet instantly reject as insufficient such a representation of it.—*Prof. O. N. Rood.*

is toned. Grass is nearly green to yellowish, blueish or purplish, or gray, a blending of many shades.

Nature's method gives a toned color, and then in the grass a red or a yellow flower as local color. This local color satisfies the desire for variety by adding to a harmony of tones a harmony of contrasted color. If the flower be examined, its effect also will be found due to tones of one color; we must look at flowers one by one to enjoy them fully.

Local color in a house or room may be bits of color in the furnishing, like single flowers in a field, the field being the wall color, which should help and not destroy the local color. The reasonable rule of room decoration would seem to be, tone the walls, let the family supply their own color contrasts in the furnishing.

This local color need not be on the chair bottoms where one sits, nor on the carpet where one puts his foot, but in the ornamental drapery and in the artistic bits of work, glass, etc.

Toning in the sense of graduated color can have no large place in decoration, the whole mass of color must be toned to a rich quality once for all. It cannot be given by change as nature gives it, but can be given in color quality. Put a little of blue, a little of green, a little of red into your grays, the quantities very minute.

Professional decoration, in the sense of house-furnishing by color, is a serious error, except in public buildings. The best of all decorations by color (on the walls of the Alhambra palaces in Granada) was in rooms devoted to their beautiful walls, having little other furniture.

Color or things will furnish; much of both gives insincerity of effect, an exhibition rather than somewhat done for itself. " Elegance," by its very superfluity of immediate impressions upon the eyes, destroys that distinctive character which marks a room or house as somebody's. This mark of individual taste may always exist where there are sincere feelings to be gratified. It is even better to show one's crude self than some other person's " refinements."

Simplicity marks the pulse of decorative art—it shows sound health ; its absence fever, or at least deteriorated healthfulness of tastes.

Originality combined with fitnesses to place, circumstances and uses marks vigorous development. A decorator impressed with conviction that simple effects alone are wholesome needs inventiveness.

Blind feeling after something new will lead to fantastic novelties. It is better to follow analogies, to go to nature for suggestions—to leaves and flowers for stencil forms and for color " motives," but one must not merely take a natural form, but also do the natural thing with it—a room is a very little place compared with the wide out-of-doors. Large, grotesque, natural-history ornamentation is out of place.

Not things, but forms and suggestions of things ; let pictures be pictures, decoration be decoration.

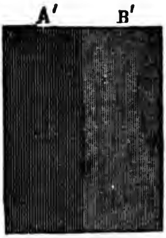
One is easily deceived by the pains he has taken, and sees his work with prejudice. It is better to be always looking for opportunity to do the natural rather than the difficult thing.

There is nothing which the painter and decorator needs so constantly to remember as the fact that his art serves construction as something inferior to it.

Always will better success be attained when the decoration seems to be the natural result of an attempt to fit the room for that special service peculiar to it. Decoration is dress for the things in the room. It is not the pictures, and should not be the furniture, so long as so much furniture is in use. It is essentially a background, a tone of feeling, a sort of atmosphere, which

> "Nimbly and sweetly recommends itself
> Unto our gentle senses."

Harmony of Color.—It is difficult to make mere words helpful in a matter depending so much upon immediate impression. There are certainly 30,000



and perhaps twenty times that number of noticeable differences in color, while there are less than a hundred words to express them, and many of these words of uncertain meaning. Only a few simple principles of color relations will be stated.

Contrast.—A lighter and a darker shade increase in difference when brought together.

> "The two surfaces A and A′ are shaded precisely alike; the same is true of B and B′. But while it is difficult to determine the difference in brightness between A and B, that between A′ and B′ is quite marked. At the same time another peculiarity will be noticed. Each of the two surfaces touching each other looks as if it were shaded off toward one side, while in reality it is covered with a perfectly even tint. Furthermore, the brighter surface appears to increase in brightness, the darker one in darkness toward the boundary line. In painting, whenever it it is necessary to avoid hard boundary lines, this contrast can be obviated by toning down on the side toward the boundary."—*Von Bezold's Theory of Color.*

A peculiarity of differences in shade is that they become greater when seen from a little distance; it is never safe to trust the contrast which they present when close to the eye. Colors and shades which are to go together should always be passed upon after examination from the distance at which they will be usually seen. Unless there is some reason for making the differences great, the darker shade of moldings, etc., should be only slightly darker than the color of the broader spaces. The lines which represent the frame or construction of a house are naturally made heavier because they are supposed to be of stronger material; the darker shade brings them out prominently, while a lighter shade would, so to speak, carry them into the darker mass of the broader spaces. But these lines should not be so dark as to entirely separate them from the building by bringing them too much under notice. A prime rule of all decoration is:

Never destroy the unity of a piece of construction.

Shades and colors must seem to belong together; a door may be broken off from the remainder of the coloring by strong contrast, for it is a movable piece by its very nature as a door; all other parts (excepting blinds, which are also doors) must be kept in place by unity of coloring to the eye, because whatever draws the attention to a thing as entirely individual breaks up its connection with other things.

Another error is using two tones of color, where there is no reason in the construction for two. It is fashionable to paint houses two colors, but this cannot be properly done except there are two parts to the surface, as, for example, in the fashionable Queen Anne style of house.

Painting the upper part of a wall another shade or color than that on the lower part is at best a sort of trick, even when divided by an unnecessary dado or frieze. If the wall is very high, as in railroad stations, it is better to break the wall. In the rooms of a private house it is easy to do so in a pretentious fashion. In the dining-room there is a real need for a dado, and the need may also exist in other living rooms. In a parlor of unusual height, a freize is not uncalled for. Morris advises breaking a wall no higher than eight feet from the floor. It is, therefore, a justifiable but a dangerous trick, because it is easy to get two colors which do not seem to be the same distance from you —the upper portion of such a painted wall often appearing to jut out or to fall in several inches. Another error in contrast of shades is in painting the niche or tube of a cornice of a room too dark and full. Color in such a niche or tube reflects against itself, and becomes much more intense, so that a very mild blue will, in such a place, become a deep blue. It is also worthy of remark that a dark or a contrasted color on a cornice brings out unpleasantly the ornamental and unnecessary character of the thing as something put on the construction.

The rule of using color in light and shade is light and shade in nature.

The first principle of harmony of color may be stated as :

Keeping a proper kinship between colors.

How to do this it is indeed difficult to state, but it should be understood that the thing is more easily and more effectively done with low colors than with bright ones.

A medium light is favorable to the greatest contrast of color. " On a sunny day the landscape generally shows but little color, but if we look at it on such a day through a very fine opening in a dark screen, such as is obtained by pricking a hole through a blackened piece of cardboard with a coarse needle, we shall at once see a greater richness of color, and above all, more intense contrasts." (Von Bezold.) *Pale, broken and darkened colors show the beauty of contrast without its harsh and tiresome effects* caused by full glaring colors.

" The fact that colors are dull or pale or grayish prevents much possibility of harshness, and the use of complementary hues excludes all risk of the brilliancy of the tints being damaged by harmful contrast. In general the lower we go in the scale, and the more our colors approximate to black, brown and gray, the more freely can we employ complementary hues without producing harshness ; and even those objectionable pairs, red and green-blue, purple and green, if sufficiently darkened become agreeable.—*Prof. O. N. Rood.*

A good rule in decoration :

Dull the fire of all strong color with black, or, better, with a very little raw umber.

Raw umber softens the light of pigments. It grays them, which is often better than to pale them with white. Delicate, pale tints have their use, however; a delicate yellow lightens a room, and is well supported by a brown pink as dado to offset its delicacy. In general, however, yellow is better light and not too positively yellow.*

In general, also, it is easier and better to work with gray colors, if they are to be contrasted. They then wake into a new life, and glow by contrast with a light "which was never on land or sea;" it is from the mind, not from the sun.

Helmholtz estimates that a painter, whose picture of an Arab in the desert, where everything is made to glare with sunlight, paints the Arab's white clothes with a white which, under the most favorable circumstances for lighting the picture, is certainly twenty and perhaps forty times less white than the actual facts of the scene. If color merely affected the eye as a drum-stick brings out noise from a drum, it would be impossible to take such a picture for the real scene. It is the mind, however, which is affected, and the mind, it should be remembered, is not a drum to be beaten, but a manufactory of ideas to be set at work; therefore, out of mere suggestions of color differences it weaves brilliant contrasts, more beautiful because they are not real but imaginary—*i. e.*, they are enlarged by the imagination.

When bright colors are used, the simplest but not always the easiest method of getting that va-

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* "In dead materials, such as distemper color, a positive yellow can only be used sparingly in combination with other tints. * * Red is also a difficult color to use; * * * there is little pleasure in it unless it is deep and full. * * The finest red is a central one between crimson and scarlet, * * but scarce to be got in flat tint. Pink * * the more orangy shades are most useful * * a cold pink * * to be avoided. * * Do not fall into the trap of a dingy, bilious-looking yellow-green."—*Morris.*

riety in color which the eye craves is by shades, such as given by the more protected portions in contrast with the lighter portions of a colored surface. Thus the more shaded portions of scarlet appear carmine; of straw-color, a golden yellow; shaded red, becomes orange red; orange-red, becomes red; orange becomes orange-red; yellowish-green, becomes green, etc. These slight differences of shade (or as Prof. Rood calls them, *small intervals**) are always harmonious because they are natural, and we instinctively regard them as belonging together. They cannot be used, however, unless there is a reason for them, which must be found in a difference in construction† (moldings, etc).

Harmony by natural, reasonable graduation of color, in this sense, is the most natural method of getting variety in decoration.

As soon, however, as we pass, in putting colors together, the bounds of what is natural, in the sense of our experience of the effects of light and shade on color, a new difficulty arises: Carmine and orange,

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* "Colors which are really related or separated only by a small interval blend harmoniously into each other and produce a good effect. The reason of this is found mainly in our preconceived ideas of the changes which colored surfaces undergo when more or less strongly illuminated."

Table of Small Intervals (Tones).

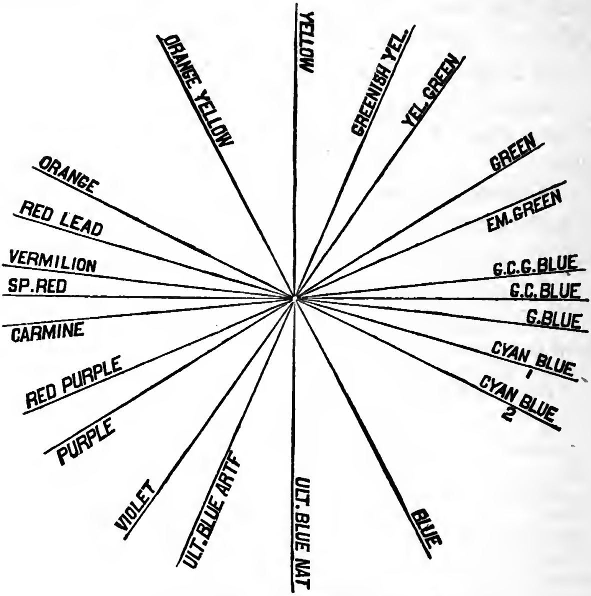
DARKER.	LIGHTER.	DARKER.	LIGHTER.
Red,	Orange-red,	Cyan-blue,	Green,
Orange-red,	Orange,	Blue,	Cyan-blue,
Orange,	Orange-yellow,	Ultramarine-blue,	Blue,
Orange-yellow,	Yellow,	Violet,	Purple,
Yellowish-green,	Greenish-yellow,	Purple.	Red.
Green,	Yellowish-green,		

"It will be noticed that the colors under the heading 'darker' are really the shade tints of the series opposite them, and the difference may often be greater than that indicated in the table."—*Prof. O. N. Rood.*

† Or in a pattern which in fact is an imaginary piece of construction.

orange and straw-color, vermilion and yellow do not agree; they are not enough unlike. And yet orange with a Prussian blue, and vermilion with a pure blue, agree exceedingly well, although they are evidently more unlike.

Contrasted Colors.—The strongest contrasts are given by complementary colors. Complementary colors are those whose mixed lights make white light. The lights may be mixed by moving the colors together quickly as on a top, or mixing them as by the lights of two lanterns. The following is a contrast diagram—colors which together make up white light



Prof. Rood's Contrast Diagram.
From Modern Chromatics.

being placed at opposite ends of the straight lines; purple and green, ultramarine and yellow, etc. (See page 306.)

"It does not follow that the colors in the diagram which are situated farthest apart always make the best combinations; for, if this were the case, the best combinations would be simply the complementary pairs, which in the diagram are placed at the greatest distance from each other, viz., opposite. But some of the complementary colors are quite harsh from excessive contrast; for example, red and its complement, green-blue, also purple and its complement, green"—these give the harshest contrasts and have been least employed in art. Divide the diagram into halves by a line drawn from yellowish-green to violet, and the left-hand section will contain the *warm* colors, the right-hand the *cold.* "After doing this we shall find that red and green-blue or purple and green are not only complimentary, but also situated at or near the positions, * * * of greatest warmth and coldness." There is therefore a double reason why these pairs of colors are not liked; their contrast is too strong and the combination harsh. The complementary colors most used in art have been ultramarine and yellow, blue and orange-yellow, cyan-blue and orange, violet and greenish-yellow. These colors are at some distance from the centre of warmth and the centre of coldness, which present excessive contrast with each other (in pairs as given), without the hardness of purple with green, etc.—*Prof. Rood.*

Contrast may be helpful or hurtful. No positive rule can be given; but in general those colors in the contrast diagram which are less than one-fifth of the circle apart weaken each the other, those more than one-fourth of the circle apart strengthen each the other, so that they seem to glow with greater fullness of color. Thus red with blue gives a good combination, with ultramarine a poor one, and with violet a bad one.

Carmine and orange, yellow and yellowish-green, orange and straw-yellow, are other samples of bad contrast. They are not tones of one color, and they are too much alike not to have injurious relations.

Emerald-green and bluish-green are apt to produce harsh effects in any but the most skillful combinations. They are too difficult as bright colors for any but the very best ability in the use of color to manage in even moderate quantity.

Cold colors alone without warm ones (*i. e.*, colors from yellow to purple) give poor combinations; nearly all persons fond of color like it warm. Finally, colors may be inharmonious because they are too bright, and therefore too harsh.

Color, above all things, must be restful and to be sought after by the eye rather than obtrusive to the eye. This restfulness is best produced by low, dull colors if contrasted, or a harmony of likeness and unity between brighter colors. Hardness, coldness and unlikeness such as produced by too great inequality in brightness must be avoided. Brilliant colors should be used with thoughts of flowers, of their pure transparent tones, and especially of their infinite little surfaces when compared with the great seas of low color.

The simplest harmony is that of tones of one color, it gives a unity and kinship to all and everything inclosed. It has been pointed out that when the yellow varnish has been removed from old pictures, the colors below often shine out into discords; they were mellowed into unity by the yellow tones of the oily atmosphere above them. This harmony of common tone in colors corresponds to the effects of dispersed light in binding together the many separate things and hues of the natural world.

On high mountains where the thin air does not intercept and break the direct rays of sunlight as does the lower air, the heavy shadows and powerful contrasts bring out the separateness of things.

The mild effect of dispersed light softens shadows and tones contrasts. A common tone in colors exerts a similar blending influence.

Colors, Good Combinations of.—While "an experienced artist can bring any two colors together," it is unwise for the majority of those using color to become ambitious; it is much better to be simple and natural in the easy sense—there are many combinations of color in nature which are very difficult to use in art.

Prof. Rood has kindly given permission to copy the following, to which he is partly indebted to Brücke and Chevreul.

* Spectral-red with blue gives its best combination.

Spectral-red with green gives a strong but rather hard combination.

Spectral-red with yellow gives an inferior combination.

Spectral-red with red lead gives a bad combination.

Spectral-red with violet gives a bad combination.

" If gold be substituted for the yellow pigment, the combination becomes excellent. Red and yellow also make a better combination when the red inclines to purple and the yellow to greenish-yellow. The combination red and yellow is also improved by darkening the yellow or both colors ; this causes the yellow to appear like a soft olive-green. (†R.) The

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* A red between carmine and vermilion.

Ultramarine is genuine ultramarine (see diagram page 306).

† Prof. O. Rood.

combination red and green is also improved by darkening both colors or the green alone."

Vermilion with blue gives an excellent combination.
Vermilion with cyan-blue* gives an excellent combination.
Vermilion with green gives an inferior combination.
Vermilion with yellow gives an inferior combination.
Vermilion with violet gives a bad combination.

"Vermilion and gold furnish an excellent combination. The combination vermilion and yellow is improved somewhat by darkening the yellow; if considerably darkened it tells as a soft olive green (R.) Vermilion and green are better when the green or both colors are much darkened. (R.)"

Red lead with blue gives an excellent combination.
Red lead with cyan-blue gives an excellent combination.
Red lead with blue-green gives a strong but disagreeable combination.
Red lead with yellowish-green gives a tolerably good combination.
Red lead with yellow gives quite a good combination.
Red lead with orange gives quite a good combination.

"The combination red lead and bluish-green is improved by darkening the green or both colors." * * *

Orange with cyan-blue gives a good and strong combination.
Orange with ultramarine gives a good and strong combination.
Orange with green gives a good combination.
Orange with violet gives a moderately good combination.

Orange-yellow with ultramarine gives its best combination.
Orange-yellow with cyan-blue gives not quite so good a combination.
Orange-yellow with violet gives a good combination.
Orange-yellow with purple gives a good combination.
Orange-yellow with purple-red gives an inferior combination.

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*Berlin blue, see diagram page 306.

Orange-yellow with spectral-red gives an inferior combination.

Orange-yellow with sea-green gives a bad combination.

Yellow with violet gives its best combination.

Yellow with purple-red gives good combinations.

Yellow with purple gives good combinations.

Yellow with spectral-red gives inferior combinations.

Yellow with blue inferior to orange and blue.

Yellow with blue-green gives one of the worst possible combinations.

Yellow with green gives bad combinations.

" The combination yellow and spectral-red is improved by darkening the yellow. (R.) Blue-green and yellow, both much darkened, give a better combination. (R.) According to Chevreul, yellow with green gives a good, lively combination ; to this the author (R.) cannot agree, although it is true that the effect is improved by darkening the yellow considerably. Chrome-yellow and emerald-green give combinations that are not bad when both the colors are very much darkened. (R.)"

Greenish-yellow with violet gives its best combinations.

Greenish-yellow with purple gives good combinations.

Greenish-yellow with purplish-red gives good combinations.

Greenish-yellow with vermilion gives strong but hard combinations.

Greenish-yellow with spectral-red gives strong but hard combinations.

Greenish-yellow with red lead gives tolerably good combinations.

Greenish-yellow with orange-yellow gives bad combinations.

Greenish-yellow with cyan-blue gives bad combinations.

Greenish-yellow with ultramarine gives somewhat better combinations.

" The combination greenish-yellow and orange-yellow is improved by darkening the latter color, which then appears brownish. (R.) Greenish-yellow and cyan-blue make a better combination when the blue is darkened. (R.)

Grass-green with violet gives good but difficult combinations.

Grass-green with purple-violet gives good but difficult combinations.

Grass-green with rose gives combinations of doubtful value.

Grass-green with pink gives combinations of doubtful value.

Grass-green with carmine gives combinations of doubtful value.

Grass-green with blue gives combinations of doubtful value.

"The value of the last four combinations is a disputed matter. The combination green and carmine is improved by darkening both colors considerably. (R.) The combination green and blue becomes better as the green inclines to yellow and the blue to violet. (R.) The combination green and violet, according to Chevreul, is better when paler hues of these colors are employed."

Emerald-green with violet gives strong but hard combinations

Emerald-green with purple gives strong but hard combinations.

Emerald-green with red gives strong but hard combinations.

Emerald-green with orange gives strong but hard combinations.

Emerald-green with yellow gives bad combinations.

"All these combinations are very difficult to handle. Emerald-green and yellow, when both are much darkened, furnish somewhat better combinations. (R.)"

Sea-green with vermilion gives good combinations.

Sea-green with red lead gives good combinations.

Sea-green with violet gives good combinations.

Sea-green with purple-violet gives tolerably good combinations.

Sea-green with purple-red gives, simply as pairs, poor combinations.

Sea-green with carmine gives, simply as pairs, poor combinations.

Sea-green with blue gives bad combinations.

Sea-green with yellow gives bad combinations.

"The surface of the green should be much larger than that of the vermilion or red lead."

Cyan-blue with chrome-yellow gives moderate combinations.

Cyan-blue with Naples-yellow gives good combinations.

Cyan-blue with straw-yellow gives good combinations.

Cyan-blue with carmine (light tones) gives good combinations.

Cyan-blue with violet gives poor combinations.

Cyan-blue with purple-violet gives poor combinations. (See page 306.)

Cyan-blue with ultramarine gives good combinations (small interval).

"The combinations of cyan-blue with violet and purple-violet are not good, except in fine materials and light tones."

Ultramarine with carmine gives poorer combinations than cyan-blue.

Ultramarine with purple red gives poorer combinations than cyan-blue.

Ultramarine with violet gives, simply as pairs, poor combinations.

Violet with purple gives poor combinations, if extended beyond the small interval.

Violet with carmine gives poor combinations.

J. G. Crace, an English artist of experience, recommends the following as excellent contrasts :

Black and warm brown.
Violet and pale green.
Violet and light rose-color.
Deep blue and golden-brown.
Chocolate and bright blue.
Deep red and red.
Maroon and warm green.
Deep blue and pink.
Chocolate and pea green.
Maroon and deep blue.
Claret and buff.
Black and warm green.

Changes of Hue Due to Contrast.—Colors in absolute contact change in appearance, not only as to brilliancy but as to hue.

Prof. Rood has given these contrast changes in a table as follows:

PAIRS OF COLORS.	CHANGE DUE TO CONTRAST.
Red	Becomes more purplish.
Orange	" " yellowish.
Red	" " purplish.
Yellow	" " greenish.
Red	" " brilliant.
Blue-green	" " brilliant.
Red	" " orange-red.
Blue	" " greenish.
Red	" " orange-red.
Violet	" " bluish.
Orange	" " red-orange.
Yellow	" " greenish-yellow.
Orange	" " red-orange.
Green	" " bluish-green.
Orange	" " brilliant.
Cyan-blue	" " brilliant.
Orange	" " yellowish.
Violet	" " bluish.
Yellow	" " orange-yellow.
Green	" " bluish-green.
Yellow	" " orange-yellow.
Cyan-blue	" " blue.
Yellow	" " brilliant.
Ultramarine blue	" " brilliant.
Green	" " yellowish-green.
Blue	" " purplish.
Green	" " yellowish-green.
Violet	" " purplish.
Greenish-yellow	" " brilliant.
Violet	" " brilliant.
Blue	" " greenish.
Violet	" " purplish.

Decoration of Buildings.—Whatever the fashion, a building in the open country should be light rather than dark in color. Yellow harmonizes best with green foliage, red looks well in the open, and white with green blinds cannot *easily* be improved for a farm-house which is not too large. Large houses may be darker than small ones. Town houses standing near a street should not be attractive; a quiet color with slightly darker trimmings, or with the same color throughout, is much pleasanter than a parti-colored building, because one tires of the latter unless the color is peculiarly harmonious, as it is difficult to get it in such masses. A line of such houses is monotonous enough; variety must be obtained by coloring with reference to neighboring houses. There appear to be subtile associations governing taste in color.

There is a craving for some positive color effect upon a movable thing, as a car, wagon (body) or carriage—a neutral or a white movable is not pleasant; while these are the effects which give general satisfaction upon things stable, like rocks and buildings. The preference for pure color on buildings is for warm colors, but in towns they should be low rather than attractive. The more separate a house from others, the stronger and warmer its color may be.

Blinds.—Green is the most satisfactory color, and if not harmonious with the chosen house color, it is, perhaps, better to keep very near (darker or lighter) to the house color; and while it is possible to get a good contrast color for blinds, it is difficult.

Interior Decoration.—The artistic taste will have more color than the indifferent taste finds comfortable to live with; it delights in pure color but mild contrasts.

The best pure effects are given by the use of much pigment, not diluted with much white. Aside from special tastes, light must give the keynote in decorating; darker colors for the lighter rooms, and the reverse. Ceilings should be bluish or else gray or green gray; a gray which is blue because it is gray, not because there is any blue in it. Halls should be warm, and darker than the rooms opening therefrom. A warm rich green is a good wall color.

Doors.—If not to be natural wood, they may be colored (without graining) in suggestion of some wood, as mahogany, cherry, oak, etc. Venetian red, a little crimson lake and a little raw umber will give a mahogany color. One color for all doors avoids that half and half appearance of parti-colored doors, opening from a room of one color into a room of another. A *darker* (always) shade of the wall color makes an appropriate door and general wood-work color.

Walls.—It is very often sufficient to destroy by a mere tint the cold blankness of white wall. There are those who like their color and their tea by the cupful, not by the gallon. Grays, green-grays (toned with red) are the best wall colors; yellow is easily kept too yellow, or worse, made too orange; blue has its special uses, as has red in its deeper and more homely shades. A master of the art on the other side of the sea gives his full list as follows:

William Morris' List of Wall Colors.—A solid red, not very deep but rather describable as a full pink and toned both with yellow and blue; a very fine color if you can hit it. A light orangy pink to be used rather sparingly. A pale golden tint (yellowish brown); a very difficult color to hit. A pale copper color between these two. Tints of green from pure and pale to deepish and gray, always remembering that the purer, the paler, and the deeper, the grayer. Tints of pale pure blue from greenish (the color of a starling's egg) to a gray ultramarine color, hard to use because so full of colors, but incomparable when right. One must be careful to avoid the point at which green overcomes the blue and turns it rank,—or the point at which red overcomes the blue and produces woful hues of pale lavender and starch blue, which have sometimes been favorites with decorators of elegant drawing-rooms.

The tone of a wall color is its beauty; it is easy to get very near to the correct thing and miss it.

Some simple examples from the real world may be given :

WALLS.	CEILING.	WOOD-WORK.
Deep brown old gold,	Greenish blue gray,	Pine.
Quiet blue gray,	Same color,	Ash.

The old gold is made up of yellow ochre, burnt Sienna, raw umber and a very little white.

The following are several parlor decorations :

WALLS.	CEILING.	WOOD-WORK.
Yellow ivory,	Blue tint,	Satin or maple.
Old gold,	Blue or white,	Cherry—natural or color.
Terra cotta pink,	Silver green,	Mahogany or deep silver blue.
Silver green,	Silvery white,	Mahogany.

Here is a house by the seaside. The hall has wide doors, which are always open, therefore the ceiling of rooms and hall has one color—a bluish green gray, made from ultramarine, chrome yellow, white zinc and raw umber. One wants a delicate effect in a parlor—its walls are warm light pinkish gray, made from zinc white, Venetian red, yellow ochre and a little raw umber. There is stained glass at the top of the windows, of gold color, to harmonize with the walls and ceiling.

The wood-work is a brown old gold, except the timbers of the ceiling, which have a green golden hue suggesting oak.

The doors throughout the house are colored for mahogany, and the jambs of the doorways a copperish green—made from raw Sienna, yellow ochre, chroms green and white.

The dining-room is quiet peacock blue—a little cobalt blue, chrome green, raw umber and white. The library walls are a slaty gray. The hallways are soft greenish yellow—as there is no light to spare to darker color.

The bedrooms* are wall and ceiling in one tone—a warm gray, made from chrome green, Venetian red and white.

A simple house has been chosen for this description because there is no purpose to advocate elaborate decoration, which will more often be done for show than for sincere satisfaction in the thing itself.

Stencil work, however, has its place. A person with strong taste for color might choose such a room as the following: An oak timbered ceiling, the ceiling space deep blue, the side walls rich red, made from Venetian red and a little raw umber, the wood-work dark oak—from ochre, raw umber and a very little burnt umber—the chimney breast a rich mellow color resembling that of a pippin apple, and on this stencil decoration in olive.

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* It is well to have some likeness of color between the rooms on the sleeping floor of a house.

A very simple and pretty effect may be given by putting walls and ceiling in gray, slightly green, and stenciling upon this in a darker shade (very little darker) leaves, smaller and larger, irregularly placed, as though falling—making it in fact "The room of the falling leaves." Nature furnishes innumerable forms for stencil work in her leaves. Stencil work can be made more satisfactory because less mechanical—more little variations to discover—than wall paper. It is healthier, and, by adding a little year by year variety may be given to a familiar wall face without destruction of surface or familiar lines.

It is in the very nature of the color-sense to demand variety, but the sincere tastes—what one really needs for satisfaction in the things about the daily life—are many rather than much. The insincerity of display is shown by the content of even artistic tastes with a little—a few good pictures, a few fine things, a good bit of color, so that the useful things are in simple taste.

Public Buildings.—Its motive is given by its use. One's feelings do not call for anything positive or ornamental in a busy place; the "dignity" of the place alone needs expression. In a church nothing should separate the attention. Wherever there is the leisure to enjoy decoration, color subordinated to the construction is appropriate.

No building so needs the hand of a true artist as a public building, but he should be a very reasonable person. It would be impossible to give examples for either churches or other edifices, except to say that colored glass, tile and color linked with construction are more appropriate than paint, and flat distemper to be preferred to oil color.

**Interior Walls.*—Distemper is the cheapest method of treating walls with color; also the healthiest, since it does not injure the ventilation, nor soak up the animal matter thrown from the lungs as does wall paper. By stenciling, this year a little, the next a little, etc., change may be had without removal of surface. It will bear brushing, but cannot safely be washed. The best preparation for distemper is a thin, flat coat of paint. The wall should at least be sized with a mixture made of soap, alum and a little glue, tinting the size or point to color if *dark* colors are to be used or the wall is rough, as church walls are. The distemper itself, however, should never be put on in more than one coat, as it tends to peel if thick.

The glue should be covered with water, allowed to stand over night, the not absorbed water poured off and the glue melted. The color, made up with pigment and fine whiting or Paris white (or zinc white for very fine work) to a paste, is now mixed with the glue and applied cool.

The amount of water used depends upon the condition of the wall, an absorbent wall requiring more.

Oil Color.—The wall should first be primed. It is a common practice to first size the wall, but we do not recommend this. It should then be given coats of white lead with considerable oil, a little japan and some turpentine—the third coat getting two-thirds oil and one-third turpentine ; the fourth coat made very

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*We are indebted to Mr. John Law, painter, for valuable advice on some of the following details.

flat—a little japan, no oil, or sometimes a teaspoonful, well thinned with turpentine. The third coat as well as the fourth should have the full color.

The surface so produced will bear careful cleaning with a damp cloth, although it contains so little exposed oil that tints are not affected by its color change.

We cannot speak positively as to the amount of this change which would be apparent in delicate tints; some tints are mellowed rather than injured by a slight tone of yellow oil. The place to observe injurious changes is behind picture frames, or ornaments which shadow the wall; these often leave their photographs in a wall color containing much oil.

Air is probably necessary for this change in wall color, and the following seems to be a very nearly complete preventive for the little oil which it is necessary to use:

Varnish for Walls.—Materials: one gallon white dammar varnish, five ounces of white wax, one-half gallon of turpentine; dissolve the wax in a steam-kettle to avoid darkening it, and when completely dissolved add the turpentine. Let the mixture cool somewhat, and add the dammar varnish. If the varnish, when tried, is too glossy, add more of the wax.

The wax offsets the brittle quality of the dammar gum, and if sufficient be used no gloss will remain. A wall properly treated will last many years, with no change of color. Prime the wall with pure oil, without addition; on this place four coats of the color, flat, over which place the varnish. All necessity for stippling or mending is avoided, laps or brush-marks will disappear in a few days. The varnish may be used as color and varnish if preferred.

Condition of Wall.—The best wall for coloring is a smooth, white sand finish. It should be dry and hard even before the sizing is put on; and should any water spots or old leaks be in the ceiling, they should be carefully shellacked before painting. In churches, a rough wall left under float is to be preferred; always distempered.

Doing Flatting.—"In flatting walls or ceilings, two or more workmen are necessary to work together to keep the joinings always wet until finished, and they should have their scaffolding or steps arranged so that the least possible delay occurs in moving them, otherwise the paint will set at the joinings and spoil the flatting, and it is impossible to remedy such defects but by rubbing down and doing the work over again. Flatting heavy work or large spaces must be done in closed rooms; no current of air should be allowed to draw through and over the work until finished, as it will set the paint too fast to work safely. Brushes for this kind of work must be of the finest and best kind, little and evenly worn. Uneven walls and badly planed wood-work, when painted in oil color or glossed, show plainly every ridge and defect, which does not appear in flatting; thus the term "flatting." It is very seldom that walls are made perfect enough to finish with a gloss or varnish, or wood-work dressed with sufficient care, particularly on contract work, to finish with porcelain or enameled surface, or to look well when highly primed work, which will easily be accomplished if the priming has been sufficiently good and stout. A material object in flatting is the tendency of the paint to retain its original and intended purity of tint; flatting white will remain white, but finishing-coats, with even a small proportion of oil, in rooms closed or partially closed most of the time, will turn yellow, and other colors will turn darker." (Stevens.)

Stippling.—This is a process of treating the surface with the butt of the bristles, in order to give a solid effect. It requires about double time, and a full coat of color underneath. It is used for fine wall work, and, recently, for heavy (broad) wood surfaces, as it destroys brush marks and lines, and gives a full effect.

Stencils.—Draw the design on a sheet of manila stencil paper which has received a coat of oil; lay the paper on a glass to get a hard, smooth surface; cut on the lines with a knife, and give the stencil one or more coats of shellac, and it is ready for use.

The stencil oil color should be mixed with japan, and thinned with much turpentine; rub it on with a short, stiff bristle brush by a peculiar movement easily learned; on distemper color use distemper.

Mr. Edis recommends, instead of the plain flat treatment of the stencil pattern, a varied tone, given by working the brush very slightly over a portion of leaf, for example, and increasing the strength of touch and amount of color in the lower portion, by which a pleasant graduation of color is carried out; or by the use of two or more tints in the same leaf or flower, carefully blended at the moment, and worked off into delicately shadowed surfaces, by which an extremely good effect is obtained. "The general decorative effect is still as it should be in this kind of work, quite flat and simple; but infinitely greater artistic character is given to the work by the skill and feeling shown in the manipulation of the brush and in the interchange of one or two colors, to say nothing of a fairly artistic rendering and decorative treatment of the design by interchanging the stencil plates, and avoiding as far as possible any formal repetition."

Interior Wood-Work.—It is well to apply a varnish of bleached shellac in alcohol to pine wood, but not upon base-boards or those portions of doors or woodwork exposed to blows or to the heat of a register, because the shellac greatly increases the danger that the paint will shell off for want of proper foundation in the cell stuff of the wood. The use of the shellac is a choice of evils, and should be made only upon woods which contain knots and turpentine. The wood-work of interiors should be painted in white lead containing (except in priming coat) no more oil than used in grinding the lead and thinned with turpentine. The finishing coats of white should be zinc white. Three flat coats of lead, and two of zinc white in dammar varnish give a white surface which will wash, last many years, but crack coats placed over it. The last coat of dammar varnish should contain little zinc, and be flowed on, not brushed out. Old woodwork, if stained, may be treated with shellac varnish, but this will not add to the fast hold of the new paint. Painting new work should be delayed until the wood is dry otherwise the paint will retain the moisture in the wood, and probably become discolored and loosened. The walls and the air of new houses are full of moisture, and require air and heat to dry out.

The paint for interior work should be carefully strained. Stippling gives a more perfect job on broader surfaces, but requires double time.

Floors.—Paint is more durable than stain, but it is not easy to get a satisfactory tone. A fair color and a durable surface are obtained by a flat coat (more turpentine than oil) of metallic (iron) paint, covered when thoroughly dry with a coat of good varnish. The layer becomes very hard; its unsuitable lustre may be rubbed off or allowed to be worn off by the feet. The floor should be primed before painting and cracks stopped with tinted putty. To get a smooth floor, prime with oil, and fill with one coat of the scraping filling recommended on page 274. Rub this smooth with sand paper on a board, fastened like a mop on the end of a stick. Put on six sheets, one over the over, removing as the paper is worn smooth. Over this surface place a coat of good varnish. Dark floor colors show dust, but light ones are not pleasant; perhaps in light shades the most agreeable are the terra cotta colors.

Outside Painting.—White lead (see pages 121, 122, 151) is better by long contact with oil, producing as much lead soap as possible.

> Now no painter would think of affirming that the lead in this dry condition would wear any better for being pure, for it soon washes off. One of the best things I have ever found to prevent this result is to mix up the paint and let it stand as long as possible before using. By this process the oil becomes a little fatty and undergoes a chemical change which makes it of more body and more adhesive. Now if I wanted to get the most for my money on a house I owned myself, I would mix up my color three months before I used it. I would then add a very little good japan, cover it with oil, and when ready to use it would add ten per cent. of spirits to cut the fatty quality, and thin to use with the best raw oil I could get. By this means I should get a material in many points resembling varnish, without its liability of cracking. I feel assured if any one wishes to try this experiment, and at the same time mixes some of the material up fresh and applies it alongside of it and watches it for one year, he will need no more argument on the question.—"*A Painter*," *in Painter's Magazine.*

English lead formerly had not only a better reputation, but positive advantages over our American lead, which probably no longer exist. Short processes of manufacture are more in use there than here, and the great advantage of age for the mixed paints, which was perhaps the principal advantage, probably does not exist to the same degree owing to quicker transportation, etc.

A friend of the writer paid a special price for English lead, painting a new house with it in two coats. After two years, the lead powdered so badly he purchased a ready-mixed paint, which has held the English lead as well as itself for four years, and shows no signs of breaking up. This ready-mixed paint had a cream color, which has disappeared, caused either by the amount of soap in the oil, or probably by containing sublimed white lead.

Sublimed white lead is a very cheap lead, with a yellowish tint, being composed of a small per cent. of litharge, the remainder being a sulphate of lead produced by a vaporizing process.* It is a large constituent of ready mixed paints.

Metallic (iron) paints are not only much the cheapest but the most durable paints for buildings, and tinted with ochres, Venetian red and white, might find a much larger use in house-painting. We present a suggestion of what may be accomplished with them tinted with yellow ochre, Venetian red and white. A terra cotta color would have given even a better effect. Iron paints or at least Venetian red appear to have a peculiar perservative action upon the surface of wood; a few coats of Venetian red will "outlast the memory of man." Metallic mixed with varnish is more durable than with oil, as we have proved on small bridges which we did not desire to paint frequently.

By using some boiled oil (*if* it can be had pure) a quicker drying paint is got, which is an important

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*By ordinary processes sulphate of lead is in crystals, and does not cover well, this covers much better.

matter in bad seasons, and a harder oil produced. If, however, the building is white, and next to another also white, recently painted with raw oil, the effect is not pleasant until the summer sun has bleached the oxy-linseed oil acid in the boiled oil.

The secret of a durable paint is, as we have shown, the production of a hard, elastic paint layer. It is claimed by some that lead with iron oxide on roofs decreases rather than increases the lasting qualities of the paint. *Roofs* certainly need a pliable paint, yet one hard enough to resist the action of the rain; and nothing is equal to fish oil,* alone or with linseed oil—the fish oil heated a little previously to drive off its water and prepare it to unite with the pigment. Spanish brown is a very durable roof pigment, but rather too warm. Yellow ochre is not too light a color, as a hot roof produces a hot house (see page 381) affecting other rooms than those immediately below it, if these are not ventilated.

Paints long mixed are more durable, but in buying ready-mixed paint there are many uncertainties, unless one has a guarantee in the reputation of the house. A *paint* secures a reputation by good quality, but is liable to deteriorate thereafter unless the house has also a reputation to sustain. As it is difficult to test a paint, there is double reason for buying a good article.

References to pages 179 and 200 will show the method by which *some* ready-mixed paints have been

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* But the difficulty is its slow drying. If, on tin, it gets the surface of the paint skimmed over before a rain, it is safe; but there is danger of its washing over other portions of the house and spoiling other work. If the roof is safely done with paint mixed with fish oil alone, it will last much longerr time than will any other paint.—*Stevens*.

made—the substance used being often water-glass (silicate of soda) in variable quantities; the temptation being strong to use all the paint would bear. It is probable that when the process of drying began (the evaporation of some of the water and the breaking up of some of the oil into glycerine and oil leather) a soap-making process accompanied it; the layer of paint produced was in fact very hard and often very durable—the writer has seen such a paint in nearly perfect condition after ten years, a portion protected by a building being in an absolutely perfect condition, with a fine lustre. Some of the paint, however (probably too little oil), would crack and peel in the worst manner, the paint curling like a dried leaf. This, I am told by an old painter who has used these paints for ten years, it was specially and decidedly prone to do if (1) any break, however small, occurred, the water seemingly shelling it off, either directly or by expanding the wood; (2) if placed over or under a lead and oil paint. We have, probably, here one of the best illustrations of the theory and the fault of a good paint. It is hard* and therefore durable, preventing even white lead from "chalking" for nearly a dozen years. But as it contains too much hardening substance for its little amount of oil, it is too hard, has no elasticity and cracks badly; moreover, the oil does not penetrate the wood (the water-glass goes into the wood), and by reason of this and the small elasticity, destruction is rapid and fatal whenever it begins, as it *may* soon.

Ready-mixed paints have undoubtedly often been

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* The water-glass hardens at once, and by it we get much the same results in this respect as by saponification as well as saponification.

made upon enlightened and economical methods, but with the temptation always at hand to replace the necessary oil with water, water-glass and other cheap dilutants. We believe that many who have purchased them at cheap rates have been better served than some who have bought pure lead and oil at much higher rates; but the number of persons who have lost both by the cracking and peeling of such paints, and by unfitness as covering for oil has been large.

As our remarks about asphaltum may be misinterpreted, it is but fair to say that an asphaltum and linseed oil paint now in the market is largely used.

Outside Painting—Season.—If convenient, fall months and warm Decembers. The wood should be dry; wait until dry from rain or dampness. Painting will not prevent shrinking, but will prevent swelling by wet if the wood is dry; if not dry, the paint will peel.

Priming.—Shellac knots. Do not flow on priming, rub it out. Prime a narrow place across the building to avoid laps. Prime fancy colors before puttying. Tint priming to color. Prime sashes before leaving carpenter's shop.

Spots.—Mix every potful uniformly to avoid spots due to unequal amounts of oil on surface. Prime open and discolored spots heavily.

Crawling.—Troublesome on glossy surfaces, and in cold weather, rub surface with a damp cloth, and rub out paint well with brush.

Avoid blisters by shellacking knots, rubbing out priming, thinner but not thin coats on tin, well rubbed, light colors on exposed doors containing pitch. Blisters are caused by wax used in graining.

Shrinking.—It is doubtful that priming prevents green wood from shrinking. Let it dry before painting; but if dry, paint before it becomes wet and swells.

Putty.—Tint putty for fancy colors.

Laps.—Avoid this by priming a few boards across the building, following the same method in painting.

Turpentine.—Little turpentine should be used in outside work—oil is needed for stability. But if there are three coats considerable turpentine should go into the *second* one.

Peeling.—Wet wood, or else ready-mixed paint at fault—see above.

Repainting.—A building too often repainted tends to crack and peel by its heavy coat. Once in three or four years is sufficient—paint properly prepared should last eight years if put on in several coats. The sun is specially destructive—parts out of the sun and not too much shaded need paint less often than parts exposed. Roofs should get one coat, not two, in repainting.

Fences.—Avoid runs by leaving no unfinished pieces over night; paint edges of pickets, rails and balusters and then the faces.

Shingles.—Prime with thin fish oil, thick dried oil in the joints catches the water which rots the wood.

Steven's House Painter's Hand-book is one of the best little books, if not the very best, ever written on the subject of painting; some of these hints (pages 417–18) have been taken by permission from it. They have been revised by two experienced painters.

Brick Houses.—Bricks do not need paint to preserve them, but to keep out moisture and allow of circulation of air through them.

1st. One-third, or more than that, of the air coming into a house comes through its solid walls. If these walls are not porous, the ventilation is reduced 25 to 30 per cent. or thereabouts ; and as it is nearly every building lives on the borders of air starvation.*

Bricks, Pettenkofer maintains, are the healthiest of building materials because they are porous and allow of such a circulation of air as not only purifies the inside of the house of carbonic acid, but also the walls of damp vapor exhaled from the lungs and from boiling water.

If the bricks are full of water, however, the pores through which the air circulates are stopped.

Common bricks absorb 16 to 20 per cent. of water.

Pressed, 2 to 7 1-2 per cent. of water.

Air does not go through a brick which contains one-sixth its own bulk of water. The whole question of the use of bricks, therefore, is to have a porous brick which will not absorb water from its weather side.

About 1⅛ lbs. of water are thrown from the lungs in 24 hours. In a house containing five people there are, besides the steam of boiling water, at least three quarts of water thrown upon the air. If the ventilation is not sufficient, if, especially, the walls are cold, because the air has access only to the surface and not to the interior particles, it will be seen that the house will quite certainly be damp from a mere accumulation of water, because the air from the lungs always comes saturated with moisture at a high temperature—about 95 degrees. As its temperature is immediately lowered, the deposit of vapor is at once commenced.

In order to test the safety of a room as regards dampness, place one and one-third pounds Troy of freshly burnt lime on a plate, and closing all doors and windows let it remain for

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*Marker and Schultze found that 1.050 cubic feet of air per hour are furnished by

21.16 square feet of free wall sandstone.
or 15.33 " " " " limestone.
or 12.6 " " " " brick.
or 9.7 " " " " limestone.
or 7. " " " " mud.

That is to say, 7 feet of mud wall or 12 feet of brick wall are equal in ventilating power to 21 feet of sandstone. It is probable that the amount of mortar has a great influence—mortar being porous.

24 hours. If the lime gains less than 20 grains in weight, the room is safe, if it gains more than one dram (or about one in 100 parts) the room is not safe for occupants.

When the wall is not furred off before plastering the plaster may suck the moisture from the brick, but in other cases, and even in this case, damp walls are impervious ones, the moisture being deposited from the inside.

Paint will reduce the ventilating quality of brick, but in cities and everywhere in the shade it is better to keep bricks dry. This may be done by partially saturating them with oil, using a sponge or a brush. The brick may then be sanded with finely powdered brick-dust if desired. The best protection, however, is given by paint—the brick being primed and then painted several coats. Care is required to prevent laps and runs.

Another method which may be used for quite porous and rough bricks, consists merely of brushing (one may say) the surface of the bricks with a thin coat of cement, over which when *dry*, coats of paint may be placed. It should be observed:

1st. The cement must be put on very thin, or it will shell.

2d. It must be protected above by cornices which will allow no water to get under the cement, between it and the house wall.

Finally, time should be allowed for it to dry before painting.

Reds, or a slightly greenish black or brown "lined" with white, are good colors for brick houses.

CAR DECORATION.

A car is a long, somewhat narrow box ; the object to make it less box-like, but not else than a car. As commonly decorated the box is lengthened by narrow stripes and lines drawn as borders to the head-linings. Already the moldings, etc., lead the eye lengthward—the seats and windows excepted, every line compels observation on the length of this box.

The Pennsylvania cars mass the decoration in squares, the long lines are broken and the attention drawn to measuring the lines of length by masses of broad decoration. Whatever the decoration upon the head-linings, it should be massed.

The lid of the box requires lifting. Commonly, a light wood is used for the panels and a dark wood in the construction of the clear-story, bringing down the box lid; the entire interior of the clear-story should be of light color, although the stencil decoration, massed as we have indicated, may be darker; for an example, an olive (stenciled foliage) on a ground of gray a trifle blue. These are the principles: That stripes and lines lengthward increase this dimension, those at right angles to it increase the apparent breadth; highth may likewise be increased by lines perpendicular, as color bands from the window panels across the side linings into the clear-story. Finally, a light color in the wood and on the lining carries up the clear-story as a seeming space filled with light.

The colors used must be soft and low; if bright and hard, pity the poor traveler! He has no escape from the glare of overhead color except by the window; but this avenue may be made more attractive for him by a frame to those ever-changing pictures seen through it. Who has looked from a barn floor through a barn door in summer knows that a view is enchanced in value by a frame—

always by a conventional frame; inimitable nature framed in a copy of itself (vines, flowers, etc.) gives only sad reflections. Already the box is sufficiently inflammable, but papier maché properly treated* will not make it more so, and will give a cheap forming material, easily removed and replaced; with such material the frame is easily constructed.

Car Colors will be chosen for appearance rather than for durability; and should be some tone of a positive color, not a pale tint nor a dark shade.

They should be chosen with reference to their effect when covered with cinders, for this is the normal condition on through routes; on local trains cars can be and are kept in better condition.

Our experience bears out fully the results of the following experiment made by Mr. William Davis some years since.

Some six months ago I prepared five samples of the different colors that are at present in general use on railway coaches, two of yellow and two of dark Pullman color, also one of Tuscan red, glazed over with Munich lake; these colors were all mixed differently, those of the yellow being mixed as follows: One of equal parts of tub lead, orange chrome and golden ochre, the golden ochre and orange chrome being ground in japan; this color I thinned down with turpentine and a small portion of raw oil to allow of its working easily. The other color I mixed with equal portions of lemon chrome, golden ochre and tub lead, all ground in oil; this I thinned with one part raw oil, two parts turpentine and two parts japan. The dark colors were mixed in the proportions of seven pounds of burnt umber and five pounds golden ochre, and thinned the same as the yellows.

The Tuscan red was ground in japan and thinned with turpentine and a small portion of raw oil. These samples were all exposed in the sun on the south side of my shop, and the result so far is in favor of those colors that were ground in oil, the light yellow

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* With asbestos or other non-inflammable substance.

being best of all. On examining these colors closely I find that those ground in japan seem to have a porous or spongy look, and to absorb the coats of varnish rather more than those ground in oil, the light yellow appearing to have the most solid surface, followed by the dark yellow, and next by the dark color ground in oil, the light yellow also appearing to keep its color better than the dark yellow, but both having a tendency to darken.

That of Tuscan red glazed with Munich lake stands equal to any but is rather too expensive to adopt as a general color for regular passenger coaches.

There is another consideration in favor of light colors; they are not apt to show the defects in both wood and surfacing so readily as the dark colors will do. It being necessary to be more particular in getting up a surface for the dark colors, adds to the expense of a coach; besides it is necessary to keep them washed and to revarnish oftener than those painted a light color. I do not go so far as to say that yellow is the only color that should be used, but give it the preference as yet of the samples I have so far tested.

The Master Car Painter of the Wason Manufacturing Company at Springfield made the following experiment:

A prepared set of panels (the back being painted) was divided into five sections. Four of the sections were then primed with oil and white lead, followed by two coats of lead, rough-stuff and the color coat one half of each panel being in orange, the other half in the Pullman color. On each of these four panels there was then used a different make of varnish.

* * *

The panel was then exposed to sun and rain* for fourteen months.

Of the four sections of the panel which I have classed together, no portion in the darker or Pullman tint remained intact. The varnish on one of these sections was evidently somewhat superior to the others in durability, but it had protected only the centre of its panel; above and below, the varnish and the color were well worn away. It was about the same or still more with the darker portion of the other three sections; the varnish was gone, the color had followed it, and on the butts of the panels about every-

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* The surface of a car in motion is rapidly cooled by the air, and it is, for intervals at least, in the shade. (See page 381.)

thing seemed to have disappeared, although the butts of the light portion of sections showed no such scouring. * * *

Tuscan red is one of the best colors as to appearance, although it does not of course equal the color produced by the glazing of Munich lake. Chrome yellow with white gives, if *good*, a durable color, in appearance a better one than yellow ochre ; but it should not be mixed with too much white (too pale), nor have that peculiarly yellow turnip color, which it is easily possible to get with it. A dark green car becomes by a coat of cinders a black one. A red needs some toning color ; Tuscan red begins to change within two months, but is on the whole the most satisfactory, although not the most economical color.

Filling Fine Woods.—Varnish alone is used as a filler by the best piano manufacturers ; but they use almost exclusively the darker woods. On lighter woods, so much varnish would probably appear yellow and unsightly out of the sunlight.

In Europe whiting is commonly used as the filler for all fine work, but it will not, I am told, stand in our drier climate, but gives, after a time, a dimpled surface.

Probably the most prominent filler (other than varnish) now used here is the natural silicate, or ground quartz, whose particles are like needles, and stick fast between the layers of fibres.

For coarser work, starch dissolved in turpentine is a good filler, but with time some change takes place which dimples the surface, probably from the starch becoming saturated with the not-drying oil acid.

Shellac dissolved in alcohol is much used, and does better for darker than for lighter woods. There are three objections to it. (1) It yellows with age. (2) Varnish does not so well stick to it as to starch. (3) Water turns it white.

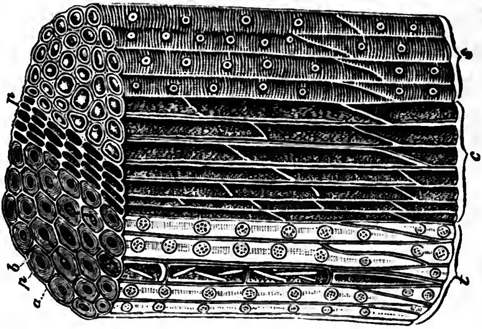
Varnish Filling.—Pianos afford such large unbroken surfaces that the light reflection must be almost perfect in its regularity (as to direction). In some manufactories the wood is first colored with some peculiar substance, which gives it the required shade and uniformity, and at the same time cleanses it of resin and glue (from the other side of the veneer). It is then filled with from three to six coats of cheaper kauri or perhaps manila varnish; afterward scraped to a perfect surface and varnished with rubbing varnish of better "gum" (three coats). This is rubbed down with ground pumice stone on felt cloth, and one or more flowing coats added, and rubbed with pumice stone and rotten stone on felt. The final polishing is with the soft bare hand, a hard, callous hand being unfitted for this work. The final finish is a spare coat of oil put on with great skill, and often finally spread by the use of a handkerchief sprayed with alcohol.

One reason why rosewood pianos are apt to scale is the artificial taste of buyers. They demand a uniform and blackish color, which does not belong to the average wood.

A coat of asphaltum varnish is therefore first placed on the wood, and whether it does not adhere, or the resin varnish does not adhere to it, a peculiar scaly appearance is apt to arise with time.

Changes in Appearance of Wood.—On mahogany and such woods the yellowing of oil is probably no great injury, because the yellow (or rather red) color combines well with the color of the wood. Not so, however, with lighter woods; when these yellow (as some of them do without oil), they take on a sickly cast.

Filling Wood.—In filling wood, the painter needs to study the course of the fibres in order to leave the filling in the hollows between them. Color the filling darker than the wood, if the wood is to be stained. But color or stain should be used as little as possible. It is hardly honest to use aniline colors for this purpose, since they fade, and coloring wood is a process once for always.



Burnt Sienna is the most durable and best stain for mahogany; bistre gives the best oak color. Logwood is much used, but is probably not stable.

Gold Leaf and Gilding.—Gold leaf is sold in books of 25 pieces; these should not have been exposed to dampness, but nevertheless it is an advantage to warm them before using the gold, as the leaves are then more easily detached. Florence gold leaf is thinner than domestic or than English. Pale leaf gold is an alloy of silver and gold, and does not stand well out-of-door exposure. Dutch gold is copper colored by fumes of tin, and has small value. Gold leaf is prepared from gold containing about 1¼ per cent. of alloy, in ingots or little molded masses, which are rolled into "ribbons" or sheets of about $\frac{1}{800}$ of an inch in thickness. These sheets are an inch square, are placed between gold-beaters' skin (membranes from the intestine of an ox) and hammered, divided into quarters and again placed between leaves, and beaten until the required thinness is obtained.

The thinness of the gold leaf not only reduces the necessary amount of the precious metal, but it makes imperceptible all joinings of pieces and leaves in the gilding.

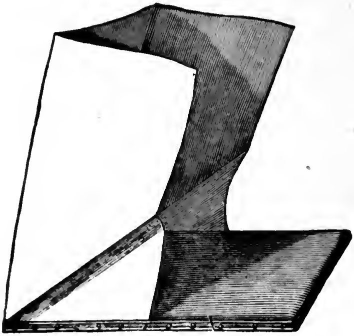
The medium colored leaf is the best for out-of-door use. Little need be said of the method of working, as this should be learned under a master and by experience, not from a book. If a "tip" (a flat brush of soft hair) is used, there will be economy in the use of gold, but a loss of time which *may* more than offset the saving in gold.

The best adhesive for the gold leaf is *fatty oil*, made by exposing to the sun linseed oil in a bottle (partly uncorked). Air is required for the oil, but it must be protected from moisture, and a year is not too long a time for the making. It should be colored with a little chrome yellow, and is then an excellent gold size, *but must never be used under varnish*, for if varnish be put over the gold, the gradual and continuous drying of the size (oxy-linseed oil acid) will crack it. If the gold leaf must be varnished (it is better as gold color without it), use English gold size or gilding sizing.

To prepare the surrounding surface, cover the ground with a fine dust from a "pounce bag," which is made by tying up in a piece of coarse muslin or woolen rag some dry pigment, whiting being generally the best.

Second, by washing the surface over with the white of eggs, and allowing it to dry before laying on the sizing.

Third, by cutting a potato in halves, and rubbing the freshly cut surface over the work, which, when dry, gives a thin film of potato starch.



Gilder's Cushion. (*Open.*)

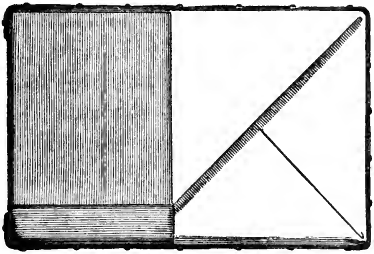
Fourth, by rubbing the work over with whiting mixed with water, and allowing it to dry.

These last methods are apt to produce ragged edges—the first is the best.

On silk, muslin, or other fibrous materials, the design should first be laid with either parchment size, the white of an egg, or pale shellac varnish.

Gilding upon plate glass has more brilliancy than the same quality of gilding upon common sheet glass, and gilding upon a finely prepared surface and over the most brilliant and glossy size is equally superior to that done over a poor surface and poor sizing, therefore, to produce good work, the surface must be smooth, and the sizing one that will flow smoothly and without fat edges.*

Never attempt to put the gold on to the size until it has the proper "tach," about which fact you can experiment with a piece of leaf, rubbing a piece of raw cotton over the leaf; if the requisite stickiness exists, the cotton moves easily over the gold, if the size is too fluid, the cotton catches, and the hand detects a motion in the leaf.



Gilder's Cushion. (Closed.)

Put only one coat, or as few coats of varnish over gold, as possible, and if the best appearance is desired put none. Varnish brings out color light, but the color of gold is the surface light reflected from its immediate surface; varnish both yellows the gold and destroys some of its brilliancy.

If all the light could be taken from the surface of gold, and only the light coming through the gold particles be seen, the color of gold would appear green or blue, for blue or green is its true color, as may be partially discovered by holding up a very thin piece of gold leaf between the eyes and the bright sky.

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*F. B. Gardner.

Gold should be laid on a white or yellow ground—chrome yellow is the best, and the effect of the gold is increased by lines of black, as there is thus the greatest contrast produced between light and its absence.

Silver leaf is less used than gold, as it is tarnished by the air. Aluminium leaf claims to be stable, and may prove a valuable substitute.

Tower clock faces may be prepared to last many years by coating them with tin-foil and gilding upon this.

Bronze colors are made by alloying zinc with copper; they are in several shades of gold, red, etc.—the gold is better fitted for interior decoration than gold leaf, as it can be applied by a brush, using either the liquid sold for this purpose or japan. The gold bronze darkens somewhat, but if properly protected by the medium, not sufficiently to injure its effect. Bronze powders have, however, a strong tendency to blacken if exposed freely to the air, especially if it contain sulphur gases. Usually bronze powders are applied by a pad on to a size. Fatty oil is not to be recommended as sizing.

CARRIAGES.

Seen in the green country, especially on a shaded road, or in numbers together in the city, one feels need for color on a carriage, but not otherwise, and there is this objection to color at any time that it attracts attention and gives the " turn out " a public character—as the quickness with which any attractive coloring is appropriated by a certain stratum of bad society gives evidence.

A carriage color which satisfies a quiet taste near at hand differs little from ordinary black when seen on the road; what is needed is some sort of changeable colors like those produced on silks. A blue is of this character, but its color does not suit all tastes. A greater number of shades, and a more artistic treatment in the sense of varied but perfectly harmonious tones without any appearance of parti-coloredness, is the direction for improvement; but it can be made only by careful study; the dangers are many, and it is questionable whether the use of the thing does not properly make the necessary expenditure of time and skill seem itself discordant. The carriage should be tasteful, it need not be ornamental in even the best sense. Black should be soft and deep,* and perhaps a little raw umber would add to the softness of the prevailing blacks; depth must be given by smoothness of the colored surface and by the lustre of the varnish. Dark greens are the best of the carriage colors, and they allow of black striping on the gears, which seems more natural than color stripes. Bronze gear panels are the most harmonious accompaniment of a black body; and there is more unity by harmony of likeness than by harmony of contrast on the gears. A bright color on wheels and gears easily looks cheap, if it lacks that richness of tone which glazing best gives.

Even the carmine of stripes looks better toned with a little black, to satisfy the eye with the car-

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* A good black is a very dark blue, and more blue adds depth—which is a product of many causes, but coming especially by seeing one surface through another. A blue ground seen through a black would be the ideal effect—as it is we rely on the varnish. But too much varnish light is like too thick plate glass.

riage when not in motion. A rich brown comes after a dark green as body color. Stripes on either spokes or hub or rim are not necessary, and like the stamped lines on a book cover, are convential rather than requirements of decorative treatment. A north light best shows the rich quality of carriage color, but no one should choose a carriage by this light only; in the more direct sunlight there will be all sorts of differences, due to it and to the yellow tone brought out by it from the varnish.

**Carriage Decoration, History of.*—In the early days of carriage making, paints seem to have been applied as preservatives, with little attention to their decorative effect, heavy carvings and gildings being resorted to for decoration. Then came the period of high colors and massive coats of arms on the bodies, with drapings of silks and bullions inside and out, and on the carriage part elaborate carvings; it was not until plain colors became the fashion that a smooth surface was looked upon as a necessity. This last fashion led to a complete revolution in method, and for many years color effects were subordinated to those produced by mere mechanical skill. At the time the first "World's Fair" was held in London, the fashion in fine decoration was confined to black on all parts, relieved by gold or red striping, except upon carved or scroll work, which was tipped out with gold and Sienna. There have, however, been intervals when elaborate carvings were resorted to; the writer well remembers one when a "Prince Albert" body with arm pieces and pillars of cherry, with elaborate carvings of leaves, fruits, etc., and with panels of mahog-

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* Contributed by Mr. W. N. Fitz Gerald.

any, became the admiration of thousands at state and county fairs. Its trimmings were of blue cloth and broad yellow and white laces; on the floor was a red and black carpet; but the carvings made up for any incongruity of colors—it was a feeble minority who condemned the lack of taste. During the last twenty-five years, however, there has been a steady advance in artistic carriage painting, and an equal improvement in taste in carriage trimming. Decorative carvings, ornamental iron work, high colored cloths together with bullion cords and tassels and heavy silk laces are no longer essential to fine decoration, and we may be said to have reached a period in which mechanical defects have been so far overcome that the attention of painters and trimmers is less engrossed with them and more than ever before with artistic color effects. The harmonious relations of the purer colors are well understood by our leading painters ; and their study is now of toned colors.

The true artist is able to use the strongest contrasts and to bring together colors which untoned are inharmonious, toning each so skilfully that combinations otherwise gaudy and crude are now strong but chaste; and in the production of such effects must the art advance in future progress.

The French were the first art workers to make practical use of harmony of tones as distinguished from harmony of purer colors, and leading American carriage builders were quick to see and to imitate French superiority in this respect. Not many years ago a carriage manufacturer conceived the idea of selecting carpets which should have a ground in harmony with the color used in the trimming; but an order on an English house for a green carpet with a red figure brought him a green and a red not harmonious with each other nor with the trimming colors. The glare of the large red figures was a lesson in color to the builder, and opened to him the necessity and the possibilities of toned colors, and another order for green and red in a carpet resulted in one which shed a certain warmth over all the carriage interior.

Present Styles.—The variety of colors now used is very great, in shades almost without number. Greens predominate, from the lightest and most delicate tints to the darker shades, barely distinguishable from black. There are greens with a golden tint, and with a vermilion tint; there are yellows from delicate flesh tints to those yellowish greens which are in fact toned greens, or to reddish yellows having something of the rays of autumnal sunsets; there are blues from delicate azure to the deepest indigo; there are reds from those difficult to distinguish from orange yellow through crimson to red toned browns. The production of these varying tones devolves upon the color-mixer, who must not only have an artistic perception of color differences, but possess a thorough practical knowledge of the chemical relations of the pigments used.

At present no color so predominates as to be called the fashionable one, nor is there any one style of striping in vogue. The tendency of fashion is rather toward individuality, with a disposition among those who lead it to adopt a family color or color combination.

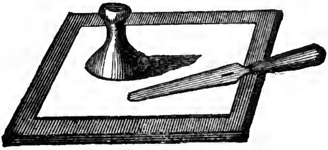
There are predominating colors, however, as green, brown, carmine, yellow, blue and the ever-present black. The combinations now found on heavier carriages are : Green panels, black moldings, carmine stripes on the body ; the carriage part a few shades darker than the body panels, and striped with carmine in one broad line or two narrow lines. Or chocolate brown panels, black moldings and a narrow cream-colored stripe ; the carriage part of the same shade of brown, broad, lined with black, and edged with cream color, or with two one-eighth inch cream-colored stripes. Or maroon panels, black moldings, and carmine striping, with black carriage part, striped with carmine. Or blue panels, black moldings, striped with a fine line of light blue, carriage part black, striped with blue. The striping is, however, far from being in set form, red is largely used on any color ; browns are sometimes striped with light greens, white or straw color. The prevailing use of silver mountings necessitates much care on the part of the decorator, as silver next certain greens results in cold and inartistic effects, while with others it is rich and attractive.

Carriage Decoration—Difficulties of.—In other decorative arts, the decorator works for fairly fixed conditions of light and shade; while the carriage decorator must produce a result fitted to a double set of conditions ; his carriage must appear artistic in the wareroom and it must produce a good and often a strong effect upon the street or on the country road under a direct sunlight. Some forms of carriage bodies present a large, others a small, surface, broken by lines which can neither be obliterated nor changed; and in all cases the carriage part is but a skeleton of such character as requires unusual skill so to decorate that it is fitted to its two conditions. A swiftly-revolving wheel whose color is not in harmony with the body color will give the portion of the latter which it covers the appearance of being in an inharmonious tint; an ornamental belt running parallel with the length of the body presents, when the carriage is in motion, a color line cutting the body into two parts, destructive to all harmony of outline. A prominent fault in carriage decoration lies in the selection of colors which do not blend—as black and white, and blue and yellow. Black wheels, striped with broad lines of white, look well in the wareroom, but when in motion the wheels present a dull gray appearance, and yellow stripes under like circumstances treat the eye to flashes of green light. Finally, the trimmer must work in accord with the painter, or all the former's labor for color harmony will easily be lost. The rules to be followed in all cases, are: Trim with materials of the same color as that upon the quarter panels and striping, or at least with colors perfectly harmonizing with these. (2) Avoid destroying unity of effect by elaborate fringes, laces, or in side mountings. Plain, rich foundations should be chosen, with minor parts which aid in bringing out the colors and the stronger outlines of the design without themselves coming into that prominence which is destructive of unity of parts.

If the carriage decorator would master his art, he must be both artist and mechanic; from the experience of others he can learn certain foundation principles, but by practice and experimental study alone can he attain success.

Carriage Colors, Matching.—It is not assumed that the art of mixing carriage colors can be otherwise learned than by practice, but some hints may be given.

In mixing use each color separately ground in japan or in varnish. Begin with a little quantity of the principal pigment of the produced color, adding a very little of another of its pigments ; mix the two thoroughly and add the third pigment (if there be a third), mixing thoroughly as before. If the shade of color to be produced has not been hit, set a little of the mixed pigments aside, adding to what remains whatever pigment seems necessary to the proper shade or tone. If the shade so produced is still "off," compare it with the little quantity set aside in order to determine whether the right direction has been taken or the right effect produced, as the case may be, as one may be working to a sample or by the eye. (See Receipts for Carriage Colors.) When proper proportions are obtained in little, the color may be mixed in quantity. It is as easy to spoil a pot of paint in an experimental trial as a quarter of a gill.

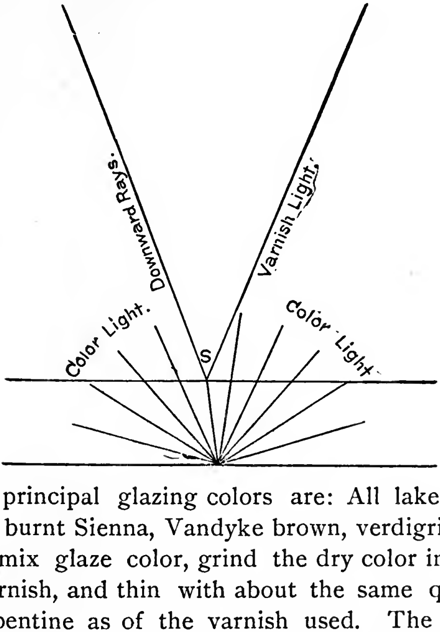


In matching old colors which have been changed by time and wear or by the oil or varnish used with them, it is well to experiment with some other than the original ingredients—*e.g.*, a little Dutch pink may give the correct shade in matching a worn color in which chrome yellow was used. In many cases a little umber added to the original ingredients of a color will give it a worn effect; if the shade is not reached add a little red to match the warm shade produced by the change in the oil.

Glazing.—There is no part of a painter's work more difficult. Glazing has for its purpose the production of transparency and an effect of depth, and the causes producing these results bring out every defect of surface. It is necessary, therefore, to use the greatest care. If a mistake is made it cannot be remedied either by mending or by additional coats, as each additional one will bring out the bad spot more plainly. Special care must be taken that the brushes used are in perfect condition, free from all "lice" and with no loose hairs. The ground color should, in general, be lighter than the glaze color, but not too light, as this involves greater danger of a cloudy effect, and requires a greater number of glaze coats to produce a perfect effect. One may glaze with blue on white, but this can be accomplished only by patience in getting the effect through a number of thin glaze coats.

As a rule the darker glaze colors are easier to use if the ground is sufficiently dark, but it is easier to glaze a vermilion ground with carmine than with Munich lake, because the contrast between the vermilion and the Munich lake color is more likely to produce a cloudy or misty effect. Two glaze coats are better than one, and three or four still better, producing a purer and deeper color. Varnish over glazed colors has much more effect than over body colors—it throws aside the white light and brings out the color light coming through the glaze.

The difference between glazed colors and body colors is in the place where the light is uncolored. By reference to page 353 it will be seen that light is uncolored, not colored, by paints, and in glazed colors this effect is produced by the light passing *through* the particles of pigment, while in body colors the color is produced by reflection from the surface of the pigment particles, or from just beneath the surface.



The principal glazing colors are: All lake colors, cobalt, burnt Sienna, Vandyke brown, verdigris.

To mix glaze color, grind the dry color in japan, add varnish, and thin with about the same quantity of turpentine as of the varnish used. The ground color surface and that of each glaze coat should be very carefully but smoothly rubbed with pumice stone, avoiding all cutting into the color.

For Receipts for Carriage Colors see Appendix.

Care of Fine Carriages.—The coach room should be large, dry and well ventilated; the walls and ceiling lined and finished in oil or varnish in order to keep out and avoid the collection of dust, which is destructive both to the cloth and to the lustre of the varnish. The windows should be large, but shaded with blue curtains; too much light (in direct rays) dries up the varnish, while dispersed light and specially dispersed blue rays are preventive of the yellow tone of varnish which destroys the beauty of colors. Dampness must be avoided, as this destroys the lustre of the varnish and affects trimmings—the carriage should not be left on a wet floor. If the stable is of brick or stone, the walls should be lined with a close board partition at least three inches from the wall, with openings at the top and bottom to allow a circulation of air; a carriage should never be allowed to stand near a brick or stone wall. Strong ammonia gas (manure fume) is peculiarly destructive to varnish, the carriage must be protected from it so far as possible.

(2) The carriage should be covered by a perfectly dry cotton or linen cover, which should never be put on while the surface of the carriage is damp.

(3) Carriages should be frequently washed, even when not in use. Mud, especially black street mud, should not be allowed to dry on the body or even on the spokes; it should be softened with cold water applied with a sponge, and from a panel entirely removed before the broad surface is washed. Hot water and soap should *never* be used—soap can entirely remove varnish. After sponging a part, dry with a shammy, but do not use the sponge and the shammy in the same water; and do not allow any part of the

surface to dry before wiping with the shammy. Choose a shady place for washing.

(4) Enameled leather while new needs little washing; it should be dusted and may be wiped with a moist shammy. If the surface has become dimmed, a suds of soft water and soap may be applied with a sponge, drying with a shammy moistened in clean water. If the leather becomes hard, it may be rubbed with neat's-foot oil; spots may be removed by linseed oil on cotton waste. Oil remaining on the surface after such applications should be washed off with crown soap suds.

(5) Trimmings require a deal of attention. All roll-up curtains and aprons should be unrolled and stretched smooth. Hinge joints should be struck, but only enough to slack the leather, not enough to fall the top. Cloths, cushions and other removable portions should be well beaten and brushed, and all immovable parts well brushed. Protection from moths as well as from dirt requires this. Morocco leather can be cleaned by rubbing with a moist shammy.

(6) Mountings should be kept clean by repeated rubbing; do not use acids nor powders, as these injure the paint, the leather and the trimmings with which they are sure to come in contact. Rotten stone may be used to clean tarnished metal, applied with a shammy, and all surplus powder removed. To clean lamps, mix whiting with spirits of wine.

(7) Carriage trimmings need careful inspection to discover moths. Musk and strong perfumes will keep the flies from depositing their eggs, but all such preventives are useless against the moth grub.

(8) A new carriage should be frequently washed;

it is the experience of manufacturers that fresh varnish so washed lasts longer than if the washing has been omitted.

(9) Carriages should be revarnished once a year; if varnished with English varnish, this should be used for the new coat.

In preparing the above the writer has followed closely, but with some changes, the *Carriage Trimmers' Manual*, by W. N. Fitz Gerald.

A FEW ELEMENTARY INSTRUCTIONS ABOUT ORNAMENTAL DRAWING, BY A HOUSE PAINTER.*

The course of study I am about to point out is within reach of all; they will find the method easy, and a source of continued enjoyment when fairly mastered. Nature shall be their instructor, for all I can pretend to do is to point out a practical mode of receiving her lessons.

1st. Your first attempts should be of the most simple nature and on a large scale, therefore begin by procuring a black painted board or slate of two to three feet square, and on it practice in white chalk the drawing of squares, circles and ovals without any guide to the hand.

2d. When you are pretty perfect in these, practice in the same way triangles, hexagons, octagons, and other figures arising from the various combinations of straight lines.

3d. Next by your circular and oval lines you may form crescents, circular and flattened volutes, regular undulations, and other figures, first making an accurate copy for yourself of each figure by measurement, and continuing to practice until you can form it by the eye with perfect ease. Avoid forming figures by little bits at a time; do each line as much as possible by one sweep of the hand.

4th. When you find yourself pretty perfect in this kind of practice, I would recommend you to draw at once from nature. You may take for your first subject a cabbage leaf, the larger the better, and persevere in copying it full size until you can repre-

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* D. R. Hay, Edinburgh, who decorated Abbotsford.

sent it accurately in outline, with its principal fibres. You may then vary your practice by other simple subjects of a similar kind.

5th. Before endeavoring to draw more than one leaf at a time. you must know a little of perspective.

The most simple mode by which you will attain such knowledge of this art as will be most useful for your present purpose is to hang a circular object, such as a hoop, between yourself and the window. Then moving it gently around and receding a little from it, you will find that as one side of it retires and the other comes forward, the circle becomes narrower and narrower, until it disappears altogether, leaving a dark line before you as if a stick instead of a hoop were there hanging. Do this before the window, because the hoop will there appear as a dark line, and you will thereby be better able to make out the change in the the shape of the circle.

Fixing the hoop in various positions, draw from it. Observe that it is a different figure from an oval. A knowledge of this simple fact is all that you will require of perspective in the meantime.

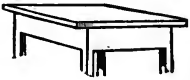
6th. You may now hang up your cabbage leaf, or a leaf of other large vegetable, observing the changes in its figures as it turns before the window.

Make an outline of its shape while half turned from you. Then place it where the light will fall upon it with its face half turned from you; and within your outline draw the principal fibres as you see them.

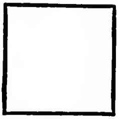
To do this properly will require a great deal of practice, but it will pave your way to being able to draw the most complete groups of flowers and foliage.

7th. Hang before you a small branch of any tree or plant with two or more leaves, the larger the better; endeavor to make their outlines, varying their shape according to their perspective. Be particular to do this correctly to nature. I knew an intelligent tradesman so unaware of the simple fact that a circular object changes in shape to the eye when seen obliquely that he returned his portrait to have all the buttons made quite round; for although they appeared so at a little distance, he had discovered "by actual *measurement*" this was not their true shape.

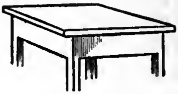
> The aspect of things is continually changing—in order to remember them at all we must have a conception of them under one definite aspect—an aspect which is often determined by quite other considerations than those of sight. This conception is apt to become mixed up in our minds with the appearance that an object presents on any given occasion.
>
> For instance, the actual appearance of the top of a square table may be that of an irregular rhomboid whose angles and size vary with every movement of the spectator. Our conception of it is that of a square, although perhaps we have never seen it under this aspect. So strongly does this conception influence our minds that even a trained artist finds considerable difficulty in drawing the top of a table flat enough, unless he is aided by perspective.
>
> The same principle may be observed in the natural tendency of any untrained person to draw the two wheels of a cart the same size, although one may be a great deal nearer to the spectator than the other and will consequently look much larger. The two wheels are known to be the same size by measurement, they are therefore supposed to be the same in appearance, the testimony of the eye being falsified by the conception formed by the mind. A great part of the use of perspective is to correct such erroneous judgments.—*A Primer of Art.*



Actual appearance.



Conception.



Tendency of the draughtsman.

To gain anything like a tolerable accuracy, this first course of lessons may require from six weeks to two months.

Lay aside your chalk and your blackboard, provide yourself with a few sheets of suitable paper and some pieces of common charcoal. Charcoal of lime-tree wood is best. Stretch a white sheet of paper upon a board by wafers, paste or pins. Place before you a cabbage, cauliflower, dock or other leaf and stalk; they will appear more picturesque if the outer leaves are hanging loose. Copy these carefully in outline, using your charcoal gently, that any inaccuracy may be easily dusted off. A large thistle with its foliage is an excellent but difficult subject—you can hardly go wrong in your choice; hemlock, fir, nettle are all worthy of study. From these the richest and most effective gothic ornaments were taken; and the more you study such subjects, the more beauty and grace will you find in their forms. I need not here remind you that the richest of pure architectual ornaments, the Corinthian capital was suggested by a basket with a weed growing around it. (?)

8th. Your next practice should be light and shade. Powder a bit of your charcoal, dip the point of your finger or better, a piece of cloth, into it, and rub it upon those parts of your outline as (in the figure which it represents) do not receive the direct light of the window, and where it appears lightest touch your copy with your chalk, leaving the clean surface of the paper as a middle tint.

9th. For the coarse paper on which you have hitherto practiced you may now substitute drawing paper. This, instead of being fixed at its corners, must be fastened around its entire edge. Exchange your charcoal for a swan quill, hair-pencil and Indian ink. You may, however, sketch your subject lightly with charcoal, as it is more easily erased; when you have it quite correct go over the lines with your black lead pencil. Rub down plenty of Indian ink, for much of the freedom of your work will depend on the wholesale way in which your shades are washed in—dilute to proper depth for lightest shades, and brush in with your camel's hair pencil. Let this first shading dry, then give another coating where the shades appear deeper, and darken the mixture for the deepest touches.

Continue this practice for six months before attempting smaller subjects. You will now find little difficulty in copying the best examples of either ancient or modern ornament that can be laid before you ; but flowers are your best subjects, as you will now (from your practice on large subjects) have obtained sufficient freedom to prevent you from getting too finical and minute.

Decorative Drawing.—It is a difficult matter to lay down rules for the use of natural forms in decoration. Natural foliage, however well rendered or cunningly carved, if merely copied from nature without translation into decorative forms by the mind and hand of the artist, will fail of its purpose, and be less effective than literal copyism from precedents.* In rendering of natural into decorative foliage there must be study and thought, with life and beauty. The beauty of the natural form must be there : but the design needs a character in accord with the rest of the architecture; it must in other words be evidently and plainly a piece of con-

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* Colling.

structed form with somewhat of that mechanical fixedness which is characteristic of human constructions.

The Study of Coloring.—The first thing to be done is to train the eye to accuracy in color as it has been trained to accuracy in form. Unfortunately, the first is much more difficult than the second. It is easy to find a teacher who can judge of accuracy in drawing; but to find one who can judge, with any nicety, of accuracy in colors is rare indeed. But in this, as in most other things, the greater part of the difficulty can be overcome by the pupil himself. Let him take some object, such as a plaster cast (an old one by preference, as this is sure to have acquired a considerable variety of tones which are well adapted to try the skill of the beginner), and place it in a good light with a simple background behind it. Let him now place his canvas with the outline of the object carefully drawn upon it in a good side light where there is no shine upon its surface. Let him then mix a color with his palette-knife to match any of the tints of the object; when he thinks he has something like the tint he should hold up his palette-knife in front of the object; if the loaded palette-knife can hardly be distinguished from the part of the object it is desired to match, then, and not till then, has the required tint been obtained. When obtained it should be transferred to its proper place on the canvas, and another part matched in the same way.

If one obvious precaution is observed, viz., that the palette knife shall have much the same light upon it that the canvas has (a full light and no shine), the operation is a very simple one, only requiring a very moderately good eye and a great deal of patience; and by its means a picture can be produced, of any simple object, which will reproduce its tints with great accuracy. The great advantage of this method for beginners is that it trains the eye to accuracy quite independently of any correction from the teacher. I may mention that it was introduced into the Slade School by Mr. Poynter with excellent results.

When this has been practiced sufficiently to give a high standard of accuracy, the student may try the method pursued by Mr. Millais. Place the canvas side by side with the object to be represented, only taking care to have it in a good light, and walk backwards and forwards between each touch, so that you are continually looking from a distance at the picture and the object placed side by side. When your picture is finished, there should be hardly any difference betwen it and the object. If there is much difference you can see what it is and correct it accordingly. This again is a method that renders the pupil to a great extent independent of any teacher. If he be honest with himself he can tell where the differences lie between his picture and the object represented, provided he can stand away from them and see them side by side. This gives such a direct means of comparison that none but a very dull eye can fail to detect a discrepancy, and if the student can only see his faults he can learn to correct them. The seeing correctly is the one important thing.

Should this method not be adopted, it is, nevertheless, highly desirable to continually look at the picture one is painting from the distance at which it is meant to be seen when finished. No amount of calculation will enable a man who is looking at a picture three feet away to tell with any accuracy what it will look like at a distance of ten feet. The experiment must be continually tried during the progress of the work. It is also highly advisable to have a looking-glass at hand. There are certain faults of distortion to which the eye readily accustoms itself. They can then no longer be detected by direct vision, but when inverted in the glass they strike the eye immediately. For instance, supposing a row of perpendicular palisades have been drawn by mistake leaning a little towards the right ; the eye soon gets used to this, and accepts all lines in the picture leaning a little to the right as perpendicular. But when these said lines are seen in the looking-glass they lean to the left, so that their divergence from the perpendicular is at once detected, in fact it appears twice as much as it really is.—*John Collier.*

APPENDIX.

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Observation and experiment show that the changed appearance noticed in varnished pictures in oil after the lapse of some years is caused in most cases by physical and not chemical influences. Time causes in these objects the discontinuance of molecular cohesion. The process begins on the surface with microscopical fissures in the varnish and penetrates by and through the different coats of colors to the very foundation. The surface and body of such a picture becomes in course of time intimately mixed with air and reflects light like powdered glass or loses its transparency like oil mixed with water and air.

The best method of rejoining the separated molecules without any danger or damage to the original is the following:

The picture is exposed to an atmosphere saturated with vapor of alcohol at ordinary temperatures (without applying heat), the resinous particles of the picture absorb alcohol from that atmosphere until they are saturated and not more.

By this process the different separated molecules re-acquire cohesion with each other, and the optical effect of the original is restored by self-action, the picture not getting touched. The small quantity of alcohol evaporates very soon when exposed to the ordinary atmosphere and the surface of the picture remains clear as long as a new varnished surface.

The most serviceable apparatus for the above purpose are some wooden cases of the size required, about three inches deep, and lined with some metal (as zinc) with the exception of the lid to which the picture or pictures to be restored are fastened by screws. in the usual manner as in ordinary packing cases.

Alcohol is poured into the metal-lined bottom of the box or case, and the lid is shut, thus suspending the pictures face downward over the alcohol. From time to time, the lid is opened in order to watch the process of the restoration and remove those paintings that have absorbed sufficient vapor. For treating a painting which could not well be removed from its place, a case without a lid and metal lining is required, one a little larger than the painting. It should be lined with some absorbing stuff (as flannel) which should be slightly sprinkled and moistened with alcohol; the case then fastened over the painting, completely covering it.

A variety of materials might replace the alcohol; wood-naphtha, sulphuric and other ethers, turpentine, benzine, etc., and in special cases higher or lower temperature may be employed.

Lead Disease.—The sufferer from lead disease should rely entirely upon some good regularly graduated physician for medical treatment. He may, however, do much for himself without use of medicine.

(1) By avoiding all contact of the skin with lead.

(2) By getting pure air—if necessary, giving up his trade for a few months (especially if he finds his weight growing less), seeking employment in some out-of-door labor. Turpentine vapors should be avoided, and may frequently be the cause of lung difficulty, as Mr. Scheller is inclined to believe, producing a peculiar susceptibility to taking cold, and, as experimental evidence shows, producing changes in the lungs.

(3) If the bowels are costive, a little sulphate of soda,* as Hunyadi Janos, may be used, as recommended in the text; but for a regular diet, fine wheat bran, raw, one tablespoonful in milk three times a day is worthy of trial *if there is no irritation* in the bowels.

This simple method is a cure for all ordinary cases of constipation; and although we can give no experience of its use in lead disease, yet it is probably *the* cure, as it tones the dull nerves of the coating of the bowels and the nerve centres in the spine.

(4) If the constipation is severe, or if there are occasional colicky pains, a belladonna plaster (a purchased one of the kind sold in sheets) should be worn for a few days placed over the bowels.

(5) If the tongue is coated, the whites of the eyes yellow, and there is a general feeling of "biliousness," a pill of one-quarter (¼) of a grain of podophylin may be taken every other night for three or four nights. The bran should be omitted while taking the pills, and for one day after the last of the series.

(6) Milk should be used in large quantities (several quarts per day), and may with advantage be used instead of meat. The milk acts upon the kidneys,† and at the same time furnishes a large amount of nutriment. Fruit and milk should not be eaten at the same meal, but considerable fruit should be used.

(7) Warm (not hot) baths should be taken at night, once or twice in the week; and a cold wash before breakfast, using merely a wet towel, if weak and chilly, and rubbing the body thoroughly with a coarse one.

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* Magnesium sulphate is the best antidote in *acute* lead poisoning. In such a case, empty the stomach with a stomach pump or with an emetic, and then give the magnesium sulphate.

† Considerable salt may be taken with the milk, if agreeable. It is *possible* that in this way the lead can be changed into soluble chloride.

Eye Exhaustion and Color.—Gaze fixedly for one minute at the star on the face of the above figure, strongly illuminated by gas or artificial light, and then upon a small dot on a white wall. Using*, instead of the figure, red, green, yellow, violet, blue paper, observe in each case the color which shortly appears on the white wall. After looking fixedly at a blackboard or other black surface, the wall will seem to be, as it is, *under lamp light* a bright yellow. These facts show how quickly any strong light exhausts the eye to its color, and affects the appearance of other colors as well as the comfort of the eye.

The exhaustion of the eye by and to color is an important factor in the changes which colors undergo when seen together. A full statement of all its relations to practice is much less necessary than a knowledge of its existence and tendency. (See page 402.)

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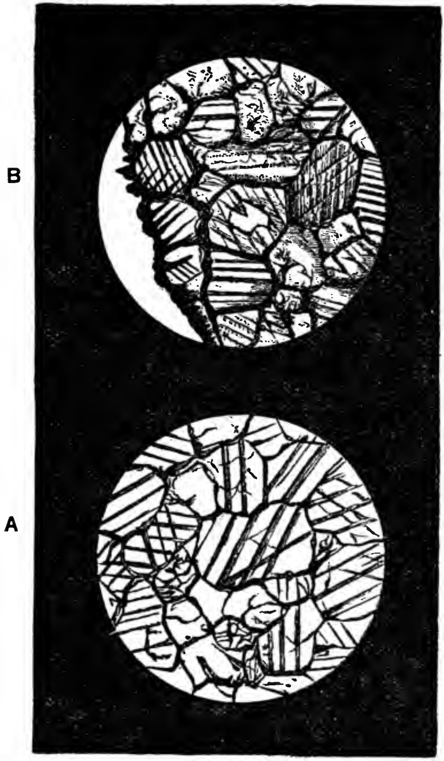
* By daylight.

PRESERVATION OF STONE.



MICROSCOPIC STRUCTURE OF OLD WHITE MARBLE TOMBSTONES IN EDINBURGH CHURCH YARD.

A is a structure of fresh marble, *B* of marble 87 years old. The black crust is sulphate of lime (and street dust), formed by the sulphuric acid of the smoky air.

The moment the crust is broken up, the decay of the stone is rapid, for we then see that beneath the smooth coherent surface-film, the cohesion of the individual crystalline grain of the marble has wholly been destroyed and that the merest touch causes them to crumble into a loose sand.

"The marble stones of our graveyards are * * * capable of imbibing a relatively large amount of moisture; * * * and as this water is frozen, its expansive force as it passes into the solid state must increase the isolation of the particles and augment the dimensions of the marble block." It is sufficient to observe that water is here the principal destructive agent. Many of our building stones are very poor and in them destructive action is much greater. Brownstone in New York may be said to be going to pieces, due, as Prof. Newbery of Columbia College is inclined to believe, to the action of the acid holding air and water in dissolving the felspars.

The felspars are composed of silica, clay and lime, or soda or potash; the last is the most soluble. Some of our sandstones contain as much as ten per cent. of lime.

Their destruction is also in some measure due to the freezing of the water which has collected in the stone on the line of the seams. There are great differences in the quality of the stone used, but the decay is so general that some method of protection or else a change of material becomes yearly more pressing.*

It is better, however, to leave any stone looking badly than to injure its ventilating power, especially if the method will result in a still worse appearance in a few years. There are a number of English stone

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* There is said to be an offer of £200, still open, to any one who will invent a paint that will preserve the new houses of Parliament, London.

preservatives, but none of which we are aware made in this country. Ransome's indurating solution, Szerelmey's stone liquid and the petrifying liquid of the Silicate Paint Co. are perhaps the best representatives of a class in which soluble silica is the chief agent of protection.

Painting is the best method where it will last, but in London, even under the most favorable circumstances, its life on stone is only about three years. Oil alone discolors the stone, and paint of course quite destroys the best appearances; paraffine oil is more lasting than linseed oil, but also discolors the stone.

Soft soap dissolved in water has been employed with some success.

But no method like these has much applicability to a city house. The same may, perhaps, be said of beeswax dissolved in coal tar naphtha, or white wax dissolved in distilled camphene, although all of these may have their use.

Silicate of soda* or potash (water-glass) and chloride of calcium deserve a thorough trial—the silicate diluted with water until the stone absorbs it freely, but the less water used the better. It should be put on with a whitewash brush carefully, so as to leave no material on the surface of the stone.

The silicate is then diluted with from one to three parts of soft water until it is thin enough to be absorbed by the stone freely. The less water that is used the better, so long as the stone is thoroughly penetrated with the solution.

The solution is applied with an ordinary whitewash brush. "After say a dozen brushings over, the silicate will be found to enter very slowly. When it ceases to go in, but remains on the surface glistening, although dry to the touch, it is a sign that the brick or stone is sufficiently charged; the brushing on should just stop short of this appearance." * * * "No excess must on any account be allowed to remain upon the face." After the silicate has become *perfectly dry*, the solution of chloride of calcium is "applied freely (but brushed on lightly without making it froth)

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* Soda water-glass is the more liquid and will penetrate better—at least so found Prof. Maier.

so as to be absorbed with the silicate into the structure of the stone." *

The effect of using these two solutions in succession is that a double decomposition takes place, and insoluble silicate of lime is formed, which fills the pores of the stone and binds its particles together, thus increasing both its strength and weathering qualities.

In some cases it may be desirable to repeat the operation, and as the silicate of lime is white and colorless, "in the *second dressing* the prepared chloride of calcium may be *tinted* so as to produce a color harmonizing with the natural color of the stone."

"Before applying this second process the stone should be well washed with rain water and allowed to dry again."

The following cautions are given in Messrs. Batemans' circular:

"1. The stone must be clean and dry.

"2. The *silicate* should be applied till the stone is fully charged, but *no excess* must upon any account be allowed to remain *upon the face.*

"3. The *calcium* must not be applied until *after the silicate is dry;* a clear day or so should intervene when convenient.

"4. Special care must be taken not to allow either of the solutions to be splashed upon the windows or upon painted work, as they cannot afterwards be removed therefrom.

"5. Upon no account use any brush or jet for the calcium that has previously been used for the silicate, or *vice versa.*"—*Notes on Building Construction.*

The difficulty with the method is the "blooming" (white powder) which often appears on the surface and discolors the stone.

"Many places in Europe, churches and other public buildings, have been refinished by the silicate, such as the Louvre and Notre Dame Cathedral in Paris, the Houses of Parliament in London, and in other cities. Still its application has met with many failures. It was found that rain counteracted the effect before the alkali has had time to take up sufficient quantity of carbonic acid from the atmosphere, and to liberate the insoluble

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* Patentee's circular.

silicate, the coatings will produce cracks and a gradual disintegration of the surface or compound caused thereby." Hence the use of the chloride of calcium, which, however, does not (probably) cure the tendency of the coating to "bloom," *i. e.*, throw out a white powder.

Coating for Outside Walls. — The following coating for rough brick walls is used by the United States Government for painting lighthouses, and it effectually prevents moisture from striking through. Take of fresh Rosendale cement three parts, and of clean fine sand one part, mix with soluble glass thoroughly. This gives a gray or granite color, dark or light, according to the color of the cement. If brick color is desired, add enough Venetian red to the mixture to produce the color. If a very light color is desired, lime may be used with the cement and sand. Care must be taken to have all the ingredients well mixed together.

In applying the wash the wall must be wet with clean, fresh water, then follow immediately with the cement wash. This prevents the bricks from absorbing the water from the wash too rapidly, and gives time for the cement to set. The wash must be well stirred during the application. The mixture is to be made as thick as can be applied conveniently with a whitewash brush. It is admirably suited for brickwork, but cannot be used to advantage over paint or whitewash.—*Feuchtwanger on Soluble Glass.*

Carriage Colors, Receipts for.—In the following receipts Dutch pink *as yellow* would give the best effects, but it is not a stable color. Chrome yellow has replaced it, but gives a sickly cast to the produced color which a little vermilion will partially cure. Verdigris will change in oil, but if used with japan (*without additional oil*) and put on in thin coats, the produced color will hold fairly well. Verdigris as a glaze offsets some of the color change produced by the varnish.

Olive Green No. 3.—Chrome yellow and black, toned with either Vandyke brown, burnt Sienna or raw umber, as warm or cold tints are desired.

Olive Green No. 4.—A common kind of olive can be made with medium chrome, Prussian blue and ivory black.

Bronze Green.—Dark Brunswick, ivory black and burnt umber.

Bronze Green No. 2.—Or deep chrome, Prussian blue and deep Brunswick.

Neither of the bronze greens requires a preparatory coat.

Finest Brown.—Indian red, toned with black, and glazed with Munich lake.

Devonshire Brown.—Preparatory coat, lamp black, deep chrome and purple-brown ; color proper, yellow burnt umber and burnt Sienna, with a small portion of crimson lake.

Hedford Brown.—Same pigments as for Devonshire brown, with different proportions. A variety of browns of different hues can be made with these pigments, with the addition of pale chrome.

London Smoke.—Black and chrome green, toned with Vandyke brown to proper richness.

Red Gears—Ground Venetian Red.—Vermilion, three coats, fourth coat as color and varnish; glaze with carmine No. 40.

Olive Brown Gears.—Umber brightened with pale chrome.

Tans for Striping.—Deep chrome, burnt Sienna and burnt umber, with a small portion of purple lake ; or deep chrome, Venetian red and burnt Sienna.

Imitation Cane.—If painted—Naples yellow.

Bottle Green.—Chrome yellow and black, toned with yellow for a warm tint.

Bottle Green No. 2.—Preparatory coat, lamp black, heightened with light Brunswick green; color proper, yellow and Prussian blue. Improved by glazing with verdigris.

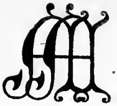
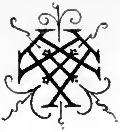
Olive Green.—Preparatory coat, lamp black, heightened with deep chrome; color proper, yellow, burnt umber and Prussian blue.

Cobalt Blue.—Ground Prussian blue mixed with white, over which ultramarine and white glazed with cobalt blue. A darker ground for glazing will give a darker color, and one more easily glazed

INDEX.

INDEX TO ADVERTISEMENTS.

Correction for page 346.— *The conditions of American Trade require that "Swiss Green" should be transferred from poisonous to non-poisonous (manufactured) Greens.*

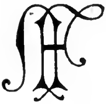



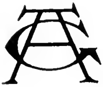










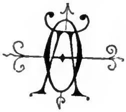








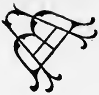
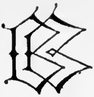










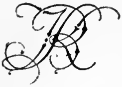



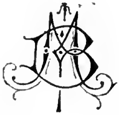


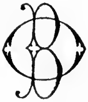



















































LIST OF
Valentine's Coach Colors.

Dark Ground Roughstuff.
Light Ground Roughstuff.
Jet Black (J).
Ivory Black (I).
Coach Black (C).
Indian Red.
Tuscan Red.
Western Red.
Eureka Vermilion.
Burnt Umber.
Raw Umber.
Burnt Sienna.
Raw Sienna.
Van Dyke Brown.
Royal Brown.
Dutch Pink in Varnish.
Dutch Pink in Japan.
Chrome Yellow, L. and O.
Railroad Yellow.
Golden Ochre.
Chrome Green, Light and Deep.
Milori Green, Light and Deep.
Royal Green, Light and Deep.
Merrimac Green, Light and Deep.
Quaker Green, Light and Deep.
The Valentine Green, Light and Deep.
Brewster Green, Light and Deep.
Ultramarine Blue.
Prussian Blue.
English Vermilion.
Purple Lake in Varnish, XX Deep.
Purple Lake in Japan, XX Deep.
Carmine Lake in Varnish, X Fine.
Carmine Lake in Japan, X Fine.
Yellow Lake in Varnish.
Yellow Lake in Japan.
No. 40 Carmine.
Munich Lake.
Geneva Lake.
Carriage Part Lake.
Rose Lake.
Rose Pink.
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The Sherwin-Williams Colors.

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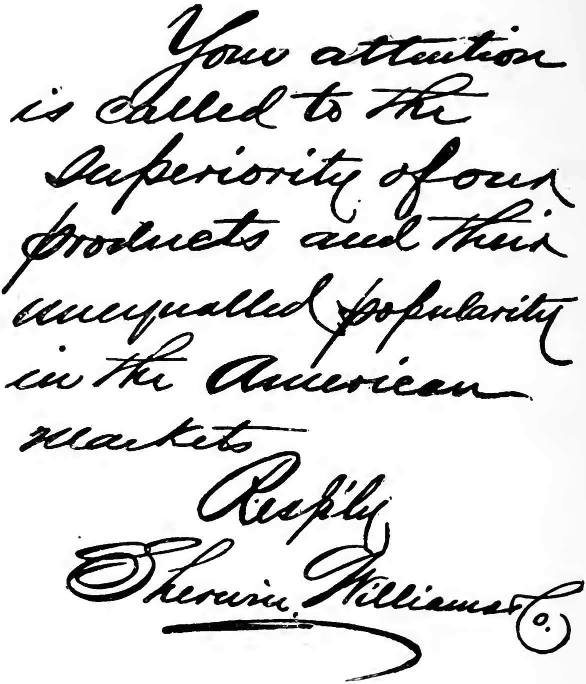

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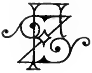

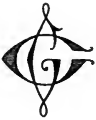













































































































































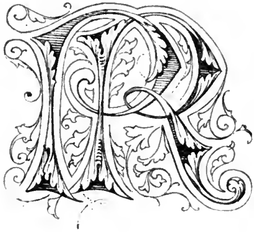






































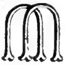



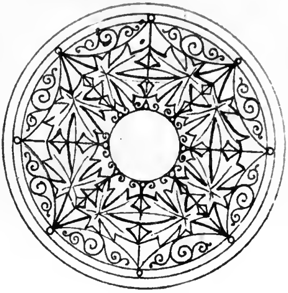

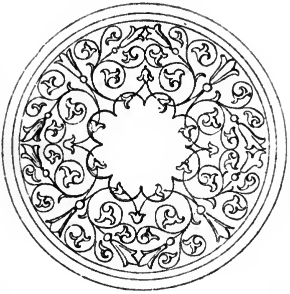

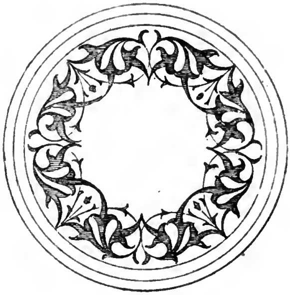

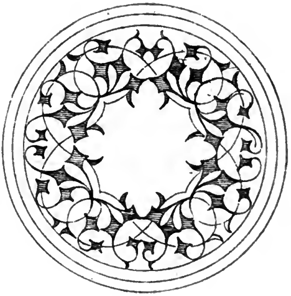

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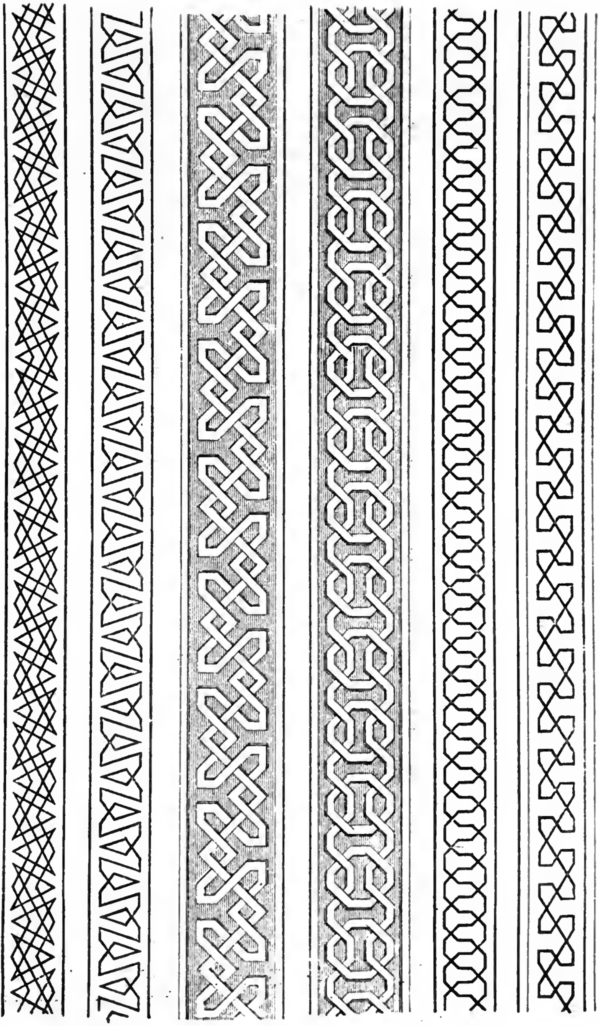

CARMINE.

Directions for Preparing and Using

CARMINE PASTE AND CARMILION.

CARMINE PASTE, although a fully established article, is not universally used to the best advantage. We premise a few remarks about the ground colors. For the light shades use: FIRST—*Carmilion—glaze twice with thin Carmine Paste; produces a rich Carmine shade.* SECOND—*Pale English vermilion—glaze twice with thin Carmine Paste; produces a scarlet shade.* THIRD—*Deep English vermilion—glaze twice with thin Carmine Paste; produces a deeper scarlet shade.* FOURTH—*English red lead—glaze twice with thin Carmine Paste; produces a scarlet shade.* FIFTH—*Orange mineral—glaze twice with thin Carmine Paste; produces a deeper scarlet shade. Orange mineral before glazing must receive a slight coat of coloring varnish, as the orange mineral contains lead, which is highly injurious to Carmine Paste.*

The ground colors for the dark shades are: FIRST—*One part of Indian red and three parts of deep English vermilion—glaze twice with Carmine Paste; produces a light maroon.* SECOND—*One part of Indian red and one part of deep vermilion—glaze twice with Carmine Paste; produces a medium maroon.* THIRD—*Indian red—glaze twice with Carmine Paste; produces a dark maroon or blood color.* FOURTH—*One part of Indian red and one part of Ivory black—glaze twice with our Carmine Paste; produces a rich, deep blood color.* FIFTH—*Three parts of Ivory black and one part of Indian red—glaze twice with Carmine Paste; produces a rich, very deep blood color.* SIXTH—*Ivory black and very little Indian red; produces a rich, black blood color.*

It is absolutely necessary that the ground colors become perfectly dry and that they be well wiped with a slightly dampened chamois to remove all dust, dimness and moisture, before any attempt at glazing is made. To prepare Carmine Paste for glazing over the above ground colors, put into a very clean or rather new and perfectly dry vessel of Carmine Paste sufficient for the work in hand, add a very little rubbing varnish and stir well; after having incorporated this thoroughly, add a little more varnish, stir well as before, and so on until the mixture is nearly as thin as rubbing varnish, then add the rest of your rubbing varnish. For the first coat, mix Carmine Paste and rubbing varnish at the rate of one pound Carmine Paste to one and a half gallons of good drying rubbing varnish; for the second coat, mix at the rate of one pound of Carmine Paste to one gallon rubbing varnish. For quick drying, use Liquid Dryer (we would recommend Pratt's Patent Liquid Dryer, as we are convinced of its superiority). Never mix any pigment or Japan with Carmine Paste, as they may contain salts of lead and other metals, which are highly injurious to Carmine Paste.

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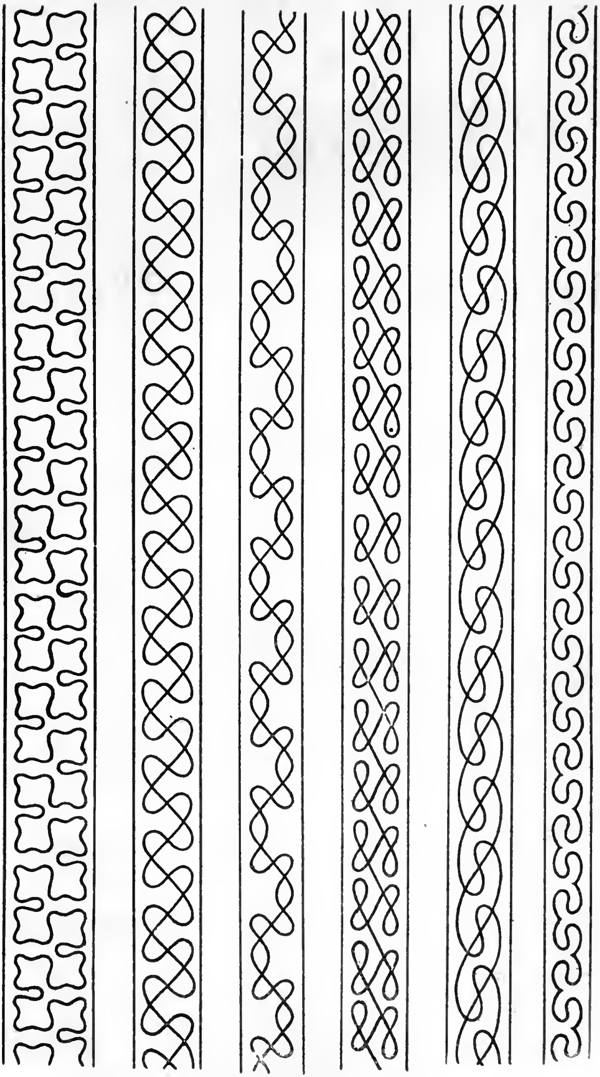

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